Pineapples, Pineapple
planting, Pineapple Processing,
Pineapple Packing,
Pineapple by products
Pineapple Industries.
fruits

*** THE HAWAIIAN PINEAPPLE.**

Cross-section of a Smooth Cayenne pineapple plant, showing crown, mature fruit, basal slip and sucker.

THE PINEAPPLE INDUSTRY

OF

THE HAWAIIAN ISLANDS

70

REPORT ON A VISIT TO THE UNITED STATES AND THE HAWAIIAN ISLANDS TO STUDY THE HAWAIIAN PINEAPPLE INDUSTRY, WITH RECOMMENDATIONS FOR THE DEVELOPMENT OF THE MALAYAN PINEAPPLE INDUSTRY

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ACKNOWLEDGMENTS.

The author wishes to acknowledge with grateful thanks the friendly reception and assistance invariably received in the course of his inquiries in the United States and in Hawaii from institution and company officials, technical specialists, research workers, plant manufacturers, plantation supervisors, cannery managers and others.

In the preparation of this report, the author has consulted and drawn fully on published literature to supplement his notes and complete his picture of the Hawaiian pineapple industry. Grateful acknowledgment is therefore made to the institutions, firms and individuals whose writings and publications are listed in Appendix II.

Acknowledgment is also made to H.H. Tengku Yaacob ibni al-marhum Sultan Abdul Hamid, Mr. R. G. Heath and Dr. T. A. Buckley of the Department of Agriculture of the Federation of Malaya, whose remarks have been incorporated in the final section of the report. In conclusion it needs to be added that this section, which deals with the Malayan pineapple industry, is an expression of the writer's personal opinions only, and is not an expression of agreed policy.

F. C. C.

THE HAWAIIAN PINEAPPLE INDUSTRY.

CONTENTS.

CONTENTS—(cont.).

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Note.

Unless otherwise stated, currency is expressed in Straits dollars, conversion being calculated at the rate of U.S. $1 = Straits $2.

The standard package in Hawaii is the folding fiberite case, delivered in two sizes; the approximate conversion rate is 1 Malayan size wooden case of 48 tins = 2 Hawaiian fiberite cases of 24 tins.

LIST OF ILLUSTRATIONS.

LIST OF ILLUSTRATIONS—(*cont.*)

LIST OF ILLUSTRATIONS—(*cont.*)

LIST OF ILLUSTRATIONS—(*cont.*)

LIST OF ILLUSTRATIONS—(*cont.*)

Acknowledgment.

Illustrations marked with an asterisk are by the Hawaiian Pineapple Co., Ltd.

Pineapple Areas Marked

Canneries ⊙

ITINERARY.

February 12th to May 4th, 1948.

1948.			
February	12th	Left United Kingdom	
	17th	New York	- H. B. M. Consul-General. Commercial inquiries.
	24th	Washington	- Agricultural Attache to the British Embassy. National Canners Association.
March	1st	Los Angeles	- British Consul. Australian Commercial Representative.
	2nd	Pasadena	- California Institute of Technology.
	3rd	San Jose Fresno	} Food Machinery Corporation.
	4th	San Francisco	- British Consul. Hawaiian Pineapple Growers Association. Mr. James Dole (formerly of Hawaii). Getz Bros. Head Office.
March 10th to April 8th		In the Hawaiian Islands	- H. B. M. Consul-General, Honolulu.
		Island of Oahu	- Department of Commerce. Pineapple Research Institute. Sugar Research Institute. Hawaiian Pineapple Co., Ltd.

ITINERARY—(*cont.*).

			Libby, McNeill & Libby. California Packing Corporation. Wailae Cattle Ranch & Dairy.
		Island of Maui	- Libby, McNeill & Libby. Baldwin Packers Co., Ltd. Maui Pineapple Co.
		Island of Kauai	- Hawaiian Canneries Co. Kauai Pineapple Co. Hawaiian Fruit Packers. Grove Farm Plantations and Smallholdings.
		Island of Lanai	- Hawaiian Pineapple Co. Ltd.
		Island of Molokai	- Plantations.
April	21st	Shanghai	- Getz Bros.
April	26th	Hong Kong	- Government House. Commercial inquiries (Formosa).
April	29th	Manila	- British Legation. Philippine Packing Corporation. Philippine Coconut Corporation.
May	4th	Arrived Singapore.	

THE HAWAIIAN PINEAPPLE INDUSTRY.

SECTION A : GENERAL.

THE HAWAIIAN ISLANDS.

History.

Although the Sandwich Islands, as they were once called, were officially discovered in 1778 by Captain Cook, there is evidence to support the view that the existence of this group of islands was known to Spanish explorers as far back as the 16th century. This early association with Great Britain is still recalled by the incorporation of the Union Jack in the territorial flag of these Islands.

2. At the time of its discovery, the archipelago seems to have been divided into three distinct kingdoms, but in 1810 after a series of conquests one of the kings, King Kamehameha, established himself as the King of Hawaii. His dynasty continued until 1893 and then, in the year following, the Republic of Hawaii was established.

3. The republic lasted only until 1900 when the islands became an organised Territory of the United States after annexation by joint resolution of Congress. Now, after 48 years as a Territory, there is a strong recommendation that the Hawaiian Islands should be admitted to statehood and so become the 49th State of the United States of America.

Geography.

4. The Territory consists of a chain of eight small islands in the North Pacific Ocean, situated just inside the tropic of Cancer, and the group is located 2,000 miles west of San Francisco and 5,000 miles east of Hong Kong. The distance from Yokohama is 3,400 miles and from Manila 4,890 miles.

5. The total area of the inhabited islands is 6,435 square miles, and the principal islands are Hawaii 4,030; Maui 728; Oahu 604; Kauai 555; Lanai 141. Honolulu, the capital, with a population of 267,710, is located on the island of Oahu. It is the industrial and commercial centre of " the Islands " and the " crossroads of the Pacific."

6. Pineapples are grown commercially on all the above-named islands with the exception of the large island of Hawaii. The largest acreage is on Oahu where there

are approximately 30,000 acres. Lanai, the pineapple island, has 15,000 acres; the other three islands, Molokai, Maui and Kauai have 18,000 acres between them.

Population.

7. The estimated population of the whole Territory in 1946 was estimated to be 519,503. Two-thirds of the people reside on the third largest island, Oahu; Lanai and Molokai, both pineapple islands, have populations of only 5,258 and 3,630 respectively; whereas on Maui and Kauai, where sugar is grown as well as pineapples, the populations are 45,336 and 34,900.

8. The people of Hawaii have American nationality, but the latest statistics reveal the surprising fact that on racial antecedents one-third of the population is of Caucasian origin, one-third Japanese or Korean, one-sixth is Hawaiian or part-Hawaiian, one-tenth is Filipino and a twentieth is Chinese. The native Hawaiians are a very happy people and bear a striking resemblance to the Maoris of New Zealand. The painstaking and industrious Japanese appear to provide the backbone of the pineapple canning industry.

Climate.

9. The climate is generally delightful,—sub-tropical rather than tropical. It is cooler than other regions in the same latitude, 22° north, and the relative humidity is low.

Sunshine.

10. In the lowlands the sky is usually either cloudless or only slightly cloudy, but the sun appears to be more powerful than it is in Malaya at 3° north. Pineapples are very liable to spoilage by sunburn and this is the reason why the large crown of the Cayenne pine is not removed in order to improve the shape of the fruit during the final stages of growth. Nevertheless pineapples in Hawaii are grown without shade, because shade trials have shown that shaded pineapples tend to remain green, are low in sugar and more acid.

Rainfall.

11. The rainfall varies considerably owing to the mountainous nature of the territory, and wet and dry areas are separated by only a few miles. One spot on Kauai, claimed to be the wettest spot on earth, has rainfall well in excess of 400 ins. per annum.

12. In the areas where pineapples are grown, the rainfall ranges from 15 to 100 ins. per annum, generally depending on the elevation. Optimum conditions are from 45 to 55 ins. with a marked and regular dry summer season which permits the fruit to ripen prior to harvesting.

13. Prolonged droughts very seriously affect yields by reducing the size of the fruit and their number, and pest infestation is said to be most serious in the hot dry areas. It is, therefore, regarded as essential that, where the rainfall is low, it must be uniform. Irrigation is practised in certain areas, and experiments in rain-making by dusting clouds with dry ice (solid carbon dioxide), so as to precipitate the moisture as rain, have been made.

Altitude.

14. Conversely, marginal conditions for the cultivation of pineapples are also to be found in the colder and wetter areas at an altitude of about 2,000 ft. The fruits are smaller and less sweet, yields are poor, and widespread plant-rot is liable to occur owing to the presence of the fungus *Phytophera cinnamomi* in the soil. This becomes more serious with successive plantings of pineapples on the same land.

15. Pineapples in Hawaii appear to do better on higher, well-drained ground, than in the lowlands. By mutual consent, sugar is grown on land which is below 300 ft. above sea-level, while pineapple is mostly planted between the 300 and 2,300 ft. levels. Between 500 and 800 ft. is regarded as the optimum under the conditions in the territory.

Wind.

16. North-east trade winds prevail almost continuously during the summer months, and, in high, exposed areas, minor, though widespread, injury is often caused by what is known as " wind-burn ". Bruising results from the rubbing of the leaves, a fungus, *Theilaviopsis paradoxa*, enters, and the leaf tip turns white.

Temperature.

17. In the various pineapples areas, the mean annual temperature ranges from 60° to 90° F. In general, in districts where the temperature is high, the acidity of the fruit is low and the fruit is insipid; conversely, in the cold areas, the fruits are small, sour and more acid. It is con-

sidered that practically no growth occurs when the temperature is below 68°F. and it is believed that fruit distortion is due to surges of growth following unusually cold spells when the temperature may fall as low as 45°F.

Seasons.

18. There is a three months dry season and its effect is pronounced. Summer-ripened fruit is much sweeter and more fruity than winter or off-season fruit. Investigators from the California Institute of Technology, studying this problem in Hawaii, found that ethyl acetate, the principal aromatic flavouring, is present in summer fruit to the extent of 120 mgms. per kilogram of fruit, whereas in the same weight of winter fruit there is only 3 mgms.

Geology.

19. All the islands are of volcanic origin and have been built up by eruption from the sea floor to a height of 13,823 ft. above sea-level. Altogether there are forty volcanic peaks, one of which, Mauna Loa (13,675 ft.) on Hawaii, is by far the highest active volcano in the world. Another, Mauna Haleakala, an extinct volcano, has a crater which is 19 square miles in extent, and is one of the largest in the world.

20. With the exception of some geological formations of recent marine origin, the rocks are entirely volcanic and consist mainly of basalt, a basic rock. In the drier areas cinder and tufa cones abound, but in the wetter areas considerable denudation has occurred resulting in the development of picturesque canyons and ravines, and in the production of alluvium.

Soils.

21. The pineapple soils of Hawaii are described as laterites of recent volcanic origin of a very similar constitution but not particularly fertile. In texture they range from clay to gravelly loams. The clays are of a very fine texture and become very sticky and heavy in wet weather, but drain and dry out very readily.

22. The organic deficiencies in these soils are corrected by regularly knocking down and ploughing in old plants, which formerly were burned. Trash samples are regularly taken and analysed for nitrogen, potassium, phosphorous and calcium content. Samples taken from the bases of the leaves of growing plants are also analysed to determine the mineral deficiencies in the soil (see Section B under "Fertilisers").

23. Thousands of soil analyses have been carried out and found to be of little value under conditions in Hawaii. Plants behave differently in their ability to make use of the various chemical elements in the soil and it has been found in Hawaii, that the plant itself is a better measure of what it can take out of the soil than any chemical extractant in the laboratory. The bases of the leaves have a more or less uniform moisture content, and it has been established arbitrarily that basal sections of the leaves provide a direct index analysis without any complications.

24. As a case in point, the soils are tremendously rich in iron but little of it is in a form available to the plant, and soil exhaustion due to iron deficiency may quickly develop with successive plantings of pineapples on the same land.

25. The pineapple soils in Hawaii can be divided into three types according to their colour which is an indication of the condition of the iron present in the soil. The chocolate-brown soils which contain iron in the readily available ferrous state are mostly to be found in the wetter areas. Under drier conditions, the soil is oxidised to the dark red ferric state, and the contained iron is not readily available to the plant. In addition there are black soils which have also been found to be not very fertile without manurial treatment because the iron is fixed as an insoluble iron-manganese complex.

26. Rainfall is an important factor in the development of acidity in the soil moisture as the bases are leached out by heavy rain, especially on higher ground. According to one authority, the pH of pineapple soils in Hawaii ranges from 7.0 (neutral) to 5.5 (somewhat acid).

THE HISTORY OF THE HAWAIIAN PINEAPPLE INDUSTRY.

27. The original home of the pineapple is considered to be Central America where it was first discovered by Columbus in 1493. During the succeeding century, explorers and traders were responsible for rapidly spreading the plant east and west around the world until, by the end of the century, the plant had reached Europe, Africa, India, China and the East Indies.

28. How or when it reached these remote islands in mid-Pacific is not known since the earliest accounts of the Hawaiian Islands make no mention of the pineapple. Plants of the Queen variety, known locally as the Kona pine, are

said to have been brought by mariners from the west in about 1805, but there is some reason to believe that the pineapple had already reached the Islands from the East prior to this date.

29. It is generally agreed that the pineapple industry owed its inception to Captain John Kidwell, a horticulturist who made the first commercial planting with the Kona pine in 1885 in the suburbs of Honolulu to supply the fresh fruit requirements of California. Later he imported many other varieties, and 12 plants received from Kew Gardens are, according to M. O. Johnson, the parent plants of the Hilo pine of Kauai. Subsequently a shipment of 1,000 plants from Jamaica in 1886, and the further importation of about a million Smooth Cayenne plants from Queensland in about 1896 provided the foundation of the Hawaiian pineapple industry.

30. The first experiments in canning were made in 1882, and, in 1892, the first small cannery was opened by Kidwell who in that first year produced only a few hundred cases. Subsequently other canneries started up and fifteen years later the annual output was over 100,000 cases; twenty years later, in 1912, it had passed the 1,000,000 mark; to-day the total annual exports are over 20,000,000 fiberite cases (10,000,000 Malayan cases).

31. The industry in Hawaii started from the same humble beginnings and at about the same time as the Malayan pineapple industry. The early canneries are described as having been housed in frame sheds, and the fruit was cut up and prepared in small batches. Cans were made by hand in Honolulu and carted about 25 miles to the plantations where the canneries were situated. The process of exhausting was omitted and the filled cans were sterilised in batches in stationary open cookers.

32. For many years the process remained discontinuous, because no conveyors were used, and the cut fruit and packed goods were repeatedly manhandled. Gradually automatic devices were introduced to speed up production and increase output. Companies began to manufacture the so-called hand-made can, using simple mechanical aids, or else they imported machine-made cans from America.

33. The turning-point in the fortunes of the industry however really came in 1906, when the annual pack was still only 74,245 cases, for in this year the American Can Company established the first factory for the manufacture

of the machine-made can in Honolulu. Subsequently the gradual evolution and perfecting of the Ginaca mechanical fruit-cutting machine made possible a progressively rapid expansion of the industry with the result that, in the succeeding forty years, the annual output has increased 250 times.

34. Many factors have contributed to the development of the Hawaiian pineapple industry. The principal are:—

(*a*) The successful cultivation of pineapples on upland soils, involving the lavish expenditure of capital (Section B).

(*b*) Mechanisation in field and factory, the streamlining of production, and the willing co-operation of the workers in the application of labour-saving and labour-easing devices (Section C).

(*c*) The utilisation of the whole of the fruit (Section D).

(*d*) The prompt application of the latest results of scientific research (Section E).

(*e*) National advertising to ensure the profitable disposal of the vast quantities of pineapple crush and juice obtained (Section F).

35. In spite of intense mechanisation and the application of every conceivable mechanical aid, about 10,000 persons are now maintained in year-round employment, while a further 10,000, chiefly students on vacation and housewives, are required in the peak season. Thousands of others, both in the Islands and in America, are directly dependant on the industry, being employed in can-making and in producing and handling the millions of fiberite cases, the hundreds of millions of labels, and the glue, wire, paint, ink, fuel, lubricants, sugar, metal, machinery, transporting equipment and other consumable materials.

SECTION B : FIELD PRACTICE.

SOIL CONSERVATION.

36. An elaborate soil conservation programme, begun in 1937, involved the exact contouring and terracing of the whole of the cultivated area under pineapples in the Islands, and the resulting regular patterning of the fields is a remarkable feature of the industry today. The new field lay-outs are designed:—

(*a*) to hold up water in the terraces so that it is forced to pass through the soil instead of over it,

(*b*) to channel surplus storm water into slow-flowing rivulets, so preventing gulch and gully formation,

and (*c*) to prevent the removal of valuable top-soil by obstructing the free run-off of water charged with silt.

This important work was carried out entirely by private enterprise, without any State aid, at an estimated cost of over $2,000,000 * for the installation of roughly 4,000 miles of road terraces on 63,000 acres of land.

Terracing.

37. The type of terracing adopted, the continuous broad-base terrace, is a broad flat-bottomed ditch with a substantial terrace ridge which strictly follows the contour. Acting as ditches for conserving moisture or for leading away surplus storm water, these terraces also serve as field roads to accommodate lorries, boom sprayers and mechanical harvesters.

38. Heavy machinery, including tractor ploughs, road graders, and carry-alls, has been employed in their construction, and once installed, these terrace-roads are usually permanent.

39. In addition, there are waterways and dams for carrying away and checking the storm waters delivered by the terraces. These waterways which follow natural channels are likewise broad flat-bottomed ditches, 10 yds. wide and only 3 ft. deep, thickly grassed to check the rush of water down the slope.

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* Unless otherwise stated, currency is expressed in Straits dollars throughout this report.

40. The grass used for lining these waterways is the variety *Panicum barbinode*, a creeping plant which grows well in moist and swampy ground. It is a weed which spreads rapidly and would invade the pineapple fields if allowed. So there is a border road, on either side of the waterway, which is kept well oiled to prevent the grass from spreading.

Contouring.

41. The employment of contour cultivation is an important requisite of this soil conservation programme. The original scheme of exact contouring was found to be too expensive in practice and it resulted in many small lozenge-shaped blocks which were not suited to mechanical cultivation and harvesting.

42. To-day fields are classified for contouring as follows:—

Steep Slopes	.. Above 8 in 100 ..	Parallel planting in wavy lines strictly following the contour.
Gentle Slopes	.. Below 8 in 100 ..	Parallel planting in straight lines approximately along the contour.
Flat Lands	.. Below 3 in 100 ..	Parallel planting in straight lines in any direction, in precise rectangular blocks.

Field Plan.

43. The terrace or contour roads, which generally run more or less parallel, are at no point more than 100 ft. apart as the mechanical boom sprayers and boom harvesters each have a 50 ft. boom. The land lying between these terraces is divided into blocks of suitable size by bisecting roads roughly set at right angles to the terrace roads. At each road junction there is a wide sweep so that these mechanical juggernauts can make an easy turn in order to go over to the other side of the block.

44. The perfect rectangular block which is only to be found on relatively level or flat land, consists of twenty-one precisely parallel beds of pineapples. Each bed has two parallel lines of very close-planted pineapples and between each bed there is a lane, 3 ft. wide, to take the wheels of the mechanical sprayers, cultivators, soil fumigators and fertilisers, which are sent through the block while the plants are growing.

45. A pineapple field is usually an irregular-shaped piece of land, consisting of a large number of precisely-patterned blocks, surrounded by a closed guard-ring consisting of six continuous and parallel beds of pineapples which extend sinuously round the boundary of the field. Just inside this guard-ring there is a parallel border road. (See para. 104).

PLANTATION OPERATIONS.

Resting the Soil.

46. Formerly, when there was plenty of available land, Panicum grass was sometimes grown in rotation with pineapples, so as to rest the land and at the same time provide pasturage and cut green feed for draught beasts then used in field operations. It is, however, a pernicious weed which is hard to eradicate. The still remaining example of crop rotation, practised only on one small plantation, is sugar and pineapples in succession, which, it is claimed, results in optimum yields of both crops. With this exception, the same land is planted repeatedly with pineapples with only a short interval between plantings, known as the inter-cycle period, during which the soil is prepared for planting.

Soil Preparation.

47. This preparation of the land takes from 6 to 8 months. The previous crop, now yellow, withered, unproductive, overcrowded and overgrown with weeds, is knocked-down with a serrated multiple-disc stump-cutter drawn by a heavy diesel tractor. In this way from 50 to 125 tons of trash are returned to the soil.

48. Subsequently the block is repeatedly ploughed and harrowed until the soil has been thoroughly churned and broken up, and the trash completely incorporated into the top 12 to 15 ins. of soil. Tractor-drawn multiple-disc harrows and ploughs are used in a total of ten to twelve operations. Finally, the surface is dragged and levelled ready for planting.

Mulching.

49. At the conclusion of this inter-cycle period comes the first planting operation. This is known as mulching, and it consists of laying down over the flattened land strips, 300 ft. long, of heavy tar-impregnated paper. This is a porous paper about .016 ins. thick, made of cheap waste material to which some rag pulp is added to give the requir-

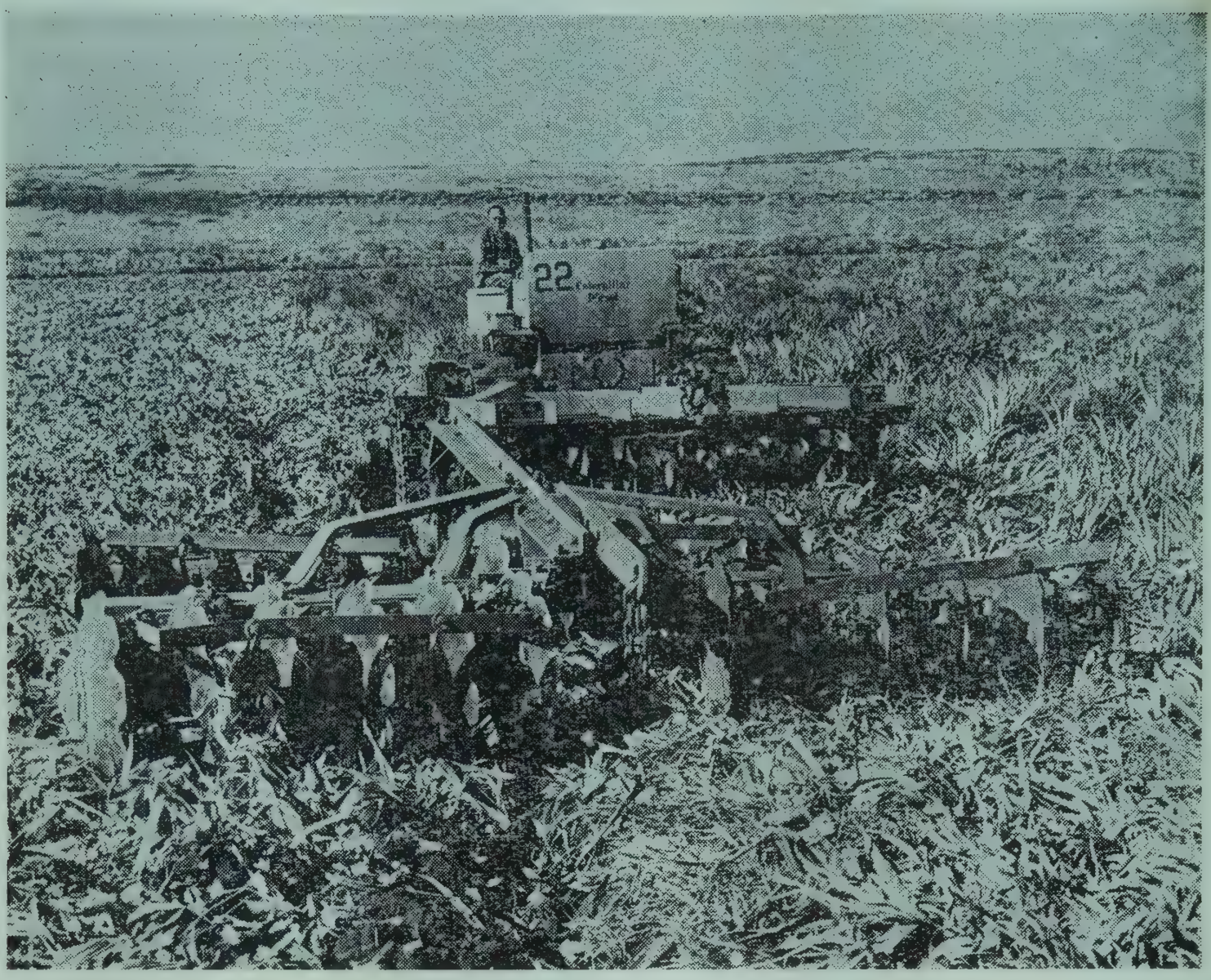
PLATE 1.

* A TYPICAL PLANTATION.

Fields are terraced and contour-planted and provided with broad-based drains to lead off storm waters. Field ready for destruction on right.

A FIELD READY FOR DESTRUCTION.

2nd-ratoon plants ready for "knocking down". Note the close wilted plants, the small size of the fruits, and the weeds.



* THE INTER-CYCLE PERIOD I.

The first step in preparing the soil is to "knock down" the old field with a multiple serrated disc harrow which cuts up the plants.

* THE INTER-CYCLE PERIOD II.

The broken trash is ploughed in with a multiple disc plough which turns over the earth to a depth of about twelve inches. Ploughing is repeated several times before the field is finally planted.

ed tensile strength for mechanical laying, as well as porosity. The asphalt which is absorbed into the paper is to prevent rapid disintegration of the paper during its exposure to the elements; sufficient is added to keep the paper intact for about 10 months. It is made in rolls, in 36 ins. and 32 ins. widths; about a quarter of a million are used annually. The 36 ins. width is most generally used, the narrower paper being used only where closer planting is necessary or possible, depending on weather conditions, soil type, and the amount of planting material available.

50. On steep slopes the mulch paper must be laid by hand, but elsewhere an ingenious machine which simultaneously fertilises and fumigates the soil and then lays and anchors the papers is used. Now it is even hoped to add mechanical planting to its repertoire.

51. The chief value of paper mulching in Hawaii can be enumerated as follows:—

(*a*) It serves to maintain soil moisture content under dry conditions near to the optimum for plant growth, since the leaves of the plant guide rain-water down under the paper where it is held.

(*b*) The black paper absorbs the heat, thus the soil temperature is maintained during the cool season and at night above that of non-paper-covered soil, so promoting plant growth.

(*c*) It serves to retain in the zone of greatest root development the nitrogen which is added in the form of fertiliser in front of the unrolling paper

(*d*) It seals the soil fumigant in the soil so that its effectiveness is maintained as long as possible.

(*e*) It suppresses weed and other vegetative growths during the first twelve months when the plants are small and do not shade the soil sufficiently to discourage such growths.

52. It is difficult to specify the exact advantages secured from its use since conditions vary, but on the average an overall 20 per cent. increase in yield is claimed, and at the Pineapple Research Field Station mulched rows of growing plants were 1 foot higher than adjacent unmulched rows of a similar age. The chief value of paper mulch-

ing appears to lie in this quick start and early development of new plantings, causing a higher percentage of the plants to fruit.

53. The total cost of mulching is estimated to be almost 3,000,000 per annum, and, in an effort to avoid this enormous annual charge, experiments are being carried out to see whether a satisfactory mulch can be obtained by destroying and laying flat the previous worn-out stand of pineapples with strong hormone solutions (see para. 122).

Soil Fumigation.

54. Fumigation of the soil during its preparation prior to planting is now standard practice to prevent the multiplication of hostile soil organisms on land planted repeatedly with pineapples. The fumigant is injected either by the aid of a mechanical cultivator, fitted with injectors and a set of hoes which seal the soil after the vehicle has passed, or more usually by means of injectors fitted to the paper-laying machines so that the paper mulch acts as a seal.

55. Soil fumigants have been found effective in destroying microscopically-small soil pests known as nematodes, and other obnoxious organisms which burrow into the roots and cause gall-like swellings which strangle the plant and result in stunted plants and very reduced yields of fruit.

56. Chloropicrin (tear gas) was used for a number of years but its cost was prohibitive and it was too volatile and unpleasant to use. A new soil fumigant known as D.D. * (not DDT), a by-product of petroleum refining, has been proved in Hawaii to be equally effective with none of these disadvantages, and, although it is toxic to humans and to plants, it can be used with reasonable safety, and is easy to apply to the soil.

57. Using 300 lbs. per acre, injected at a depth of 6 ins. into badly infected soil, it is claimed that where nematodes are a serious problem, from 10 to 20 tons more fruit can be obtained per acre. It is considered, however, that the use of soil fumigants may necessitate a revision of the fertiliser programme as the benevolent soil population,—the nitrifying bacteria,—is also destroyed when the soil is fumigated.

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* D.D. : a mixture of unsaturated chlorinated hydrocarbons produced as a by-product of petroleum.

PLATE 3.

* THE INTER-CYCLE PERIOD III.

A fumigant is injected into the earth as the paper-laying machine advances, and the soil is then sealed with three exactly parallel rows of mulch paper.

PLATE 4.

*** THE INTER-CYCLE PERIOD IV.**

Eight months after "knocking down" the field is planted. A planter can cover one-third of an acre and plant over 5,000 plants in a day.

PLANTING.

Types of Pineapples.

58. Two types of pineapple are grown,—the Smooth Cayenne and the Hilo, the latter representing only about 8 per cent. of the total crop. It is believed that the plant was carried by explorers and traders east and west from its original home in Central America, and that the Cayenne pine arrived in Hawaii from the West *via* the East Indies, while the other came directly from the East.

59. The Cayenne pine of Hawaii is merely a close-planted Sarawak pine, the size of the fruit being deliberately reduced by crowding. Its size varies from a maximum of 6 lbs. in the first or plant crop down to about 1½ lbs. or less in the second ratoon,—the third and final crop; the average size for the main plant crop is generally just under 4 lbs. The fruit has a marked tendency to be conical but will fill out to a true cylinder if its large green crown is removed during growth. Unfortunately in Hawaii, where the atmospheric humidity is low, this results in fruit spoilage by sunburn.

60. The core size of the Cayenne pine is 1¼ ins. in diameter, appreciably larger than that of the Queen pine which is ¾ ins. This is more than compensated for by its reduced eye-depth which is less than ½ in., whereas that of the Queen pine is ¾ in. or more. Undoubtedly the Queen or Singapore Canning Pineapple is much more sturdily armoured, and should be much less susceptible to bruising during transportation from the fields. This may possibly account also for its greater resistance to pests and diseases.

61. The Hilo pine appeared to be a fruit of deeper colour and translucency, and more uniform size and shape than the Cayenne, and a selection from it called the Anahula is of even better flavour and bouquet and of perfect shape. The Hilo pine also yields fine large fruits in the first ratoon or second crop. Unfortunately the Hilo and the Anahula pine do little more than maintain their numbers, and they cannot be grown in the drier regions. This is because they yield no basal slips, and, in consequence, reproduction is mainly from crown plantings which take longer to establish and so cannot stand drought conditions owing to their susceptibility to yellow spot disease.

Planting Material.

62. Planting material was described as the true capital of the Hawaiian pineapple industry since, whenever any general deterioration of the fields due to wilt, drought or other causes occurs, an acute shortage of planting material is felt, and, at any time, planting material of good quality, *i.e.* large selected slips, is hard to purchase because growers naturally retain the best for the improvement of their own fields.

63. The pineapple may be reproduced from crowns (at the top of the fruit), from basal slips (collected from below the base of the fruit), from suckers (which grow out of the leaf axils), and even from stem sections. Basal slips are the preferred planting material in Hawaii and constitute 90 per cent. of the total used. Occasionally when material is short, suckers and crowns have to be used, and crowns are used to reproduce the Hilo pine and also for the rapid multiplication of selected clones. Reproduction from stem sections is still only experimental.

64. Healthy Cayenne plants give an average of four basal slips and two or three vigorous suckers which produce the ratoon crop in the year following. It was stated that, allowing for rejections, crowns are sufficient to plant the same area, suckers will increase the planted acreage by half as much again, while slips will multiply the area as much as four times.

65. In Hawaii, crowns generally require 24 months to yield ripe fruit, suckers from 15 to 18 months, and slips from 20 to 22 months. The bulk of the planting material is available in September, and suckers planted then will thus yield sour fruit in the spring, whereas slip plantings will yield fruit in the autumn which, having ripened during the sunny summer months, is of much better quality.

66. There is a very objectionable type, known as the "collar of slips" plant, which appears to be increasing in numbers in spite of efforts to rid the fields of it by selection. It appears to develop extreme vegetative growth at the expense of the quality of the fruit. The fruit is embedded in a close nest of slips many of which even grow out of the eyes of the fruit.

The Nursery.

67. Planting material is collected after the crop has been harvested and just before the main planting season

is due to commence in the late autumn. Selection of planting material to establish separate and superior families is carried out by skilled technical officers, but the ordinary field personnel are also expected to use intelligence and judgment in the choice or rejection of planting material.

68. Selected slips are snapped off, trimmed, laid butts upward and dried directly on the mother plant. Subsequently the slips in the block are collected and taken to a nearby storage-ground, an area of field about 300 x 450 ft. in extent, where they are sorted and close-stacked, butts up, to mature in the sun until required. This is to prevent the rotting through the soft callus which would occur if the seedlings were planted at once without being properly cured.

69. A curing period of at least a week in dry weather and preferably longer is desirable. The slips are not kept on the storage-ground too long before being planted. Normally over 3 months is regarded as being too long, but under favourable conditions they can be held for as much as 5 months.

Planting Seasons.

70. Pineapples may be planted in Hawaii at any time of the year but, owing to the incidence of seasonal droughts, rains and cold weather, the results differ. The most satisfactory time of the year to plant for most areas is in late autumn just before the rains, so that the mature fruit can ripen properly during the dry summer months, 20 to 22 months later.

71. The planting year is described thus:—

1st September to 30th November	..	Autumn planting.
1st January to mid-April	..	Off-season planting.
Mid April to 30th June	..	Spring planting.
July and August	..	The peak harvest.

72. Late autumn planting with large slips will result in fruiting 22 months later, *i.e.* July and August, the main cropping months when 75 per cent. of the crop is harvested. Small slips are preferred for the spring plantings because such plants take longer to establish; ripening is thereby delayed and the fruits can be harvested in the early summer, 24 months later, *i.e.* during June. Off-season plantings result in a most unsatisfactory crop as regards size, shape and flavour, and the resulting harvest is spread irregularly over twelve months, making it necessary to visit the same field again and again to collect small amounts of fruit.

73. Planting in the spring or in the off-season is really a matter of expediency. Wherever there is a shortage of labour or of field equipment it becomes necessary to plant in these unsatisfactory periods in order to obtain enough fruit for the cannery, and to spread the work in the factory over as many months as possible.

Planting Operations.

74. The slips are brought by lorries right on to the block, the wheels of the vehicle following the lanes between the strips of paper mulch. There the planting material is dumped in successive piles at convenient points by men armed with wooden rakes.

75. The planting iron used is a flat, pointed steel blade about ⅛ in. thick, 2 ins. wide and 8 ins. long with a curving handle 4 or 5 ins. long. The paper mulch, normally 36 ins. wide, is usually marked with planting holes set 6 ins. from each edge. The plant lines are thus 2 ft. apart while the holes in each line are usually set at 1 ft. intervals and alternate so that the plants do not come directly opposite each other in the two lines.

76. The actual planting is still done by hand, although mechanical planting is being considered. The plants are first laid out along the paper strip by one man who leaves a slip beside each mark in the paper. Another man following thrusts his planting iron through the paper into the soil to a depth of about 6 ins., opens a gap and into this he firmly forces the new plant, and then withdraws the iron.

77. A skilled planter can cover about one-third of an acre and insert between 5,000 and 7,000 plants a day, for which he receives U.S. $2.90 per thousand plants for two months of intensive work.

Planting System.

78. Standard planting practice in Hawaii is as follows:—

Number of beds per block	..	21
Width of lanes between beds	..	3 ft.
Number of plant lines per bed	..	2
Distance between plant lines	..	2 ft.
Plant intervals in the lines	..	1 ft.
Number of plants per acre	..	17,454.

79. There are minor variations to suit different conditions. At higher altitudes, where it is colder and vegetative growth is less, slightly closer planting is

considered permissible. Plant intervals vary between 10 and 14 ins., and the width of the lanes are sometimes reduced to 2½ ft. to allow wider planting in the lanes with the same plant population. Plant populations now range from 16,000 to 18,000 plants per acre, compared with 7,000 plants in the early years of the industry.

80. It was found that when the plants are allowed room for free growth and subsequent ratooning the resulting fruits were of widely irregular size and shape. Some were far too small and round and some were abnormally large and had a marked tendency to be conical. With the introduction of machine-cutting, the maximum recovery of cut fruit could be obtained only with fruit of uniform size and cylindrical shape, and closer planting was decided upon to obtain fruit of more uniform size and standard dimensions to suit the requirements of the automatic peeler and corer.

81. However, while close planting has resulted in smaller and better-shaped fruit and has also given better weed-control by shading the ground with pineapple leaves, nevertheless it is to-day only occasionally possible to obtain a second ratoon (third crop) which is sufficiently large to be worth collecting. Furthermore, while close-planting increases the tonnage yield of fruit up to a point (beyond which the fruit is too small), it also causes a serious reduction in the amount of good planting material which is produced.

82. The opinion was expressed that some deterioration in the quality, shape and size of fruit was now occurring in some areas. This may be the result of repeated planting of the same crop on the same land, combined with close-planting. Fertilisers are applied to improve the size, but, with such intensive cultivation of a single crop, nematodes, mealy bugs and fungus diseases have become an increasing menace, demanding constant vigilance by technical experts.

Cultivation and Weeding.

83. The rains, which closely follow the autumn planting, ensure the success of the crop but also encourage very prolific weed growth in the lanes between the beds. Formerly weeds were laboriously and expensively eliminated by single mule-drawn cultivators and by hand-hoeing.

84. The standard method today for controlling troublesome weeds and at the same time effecting other necessary operations is by means of a mechanical cultivator fitted with weed-sprays, soil-fumigant injectors or fertiliser tubes. These high-clearance mechanical cultivators, which follow the lanes and cover a large acreage each day, are fitted with a set of spiked hoes which loosen the soil after the wheels have passed, so uprooting and eliminating all weeds except those growing close to the plants. These can be effectively dealt with by means of diesel oil emulsion sprays.

85. The spray used must not injure the plants yet it must kill the young weeds before they are able to become established. Diesel oil used alone will injure pineapple leaves, but if a special clay is added as an emulsifier it has been found that heavy applications of the resulting emulsion can be applied without damage to the young growing plants as this colloidal clay suppresses the phytotoxic properties of diesel oil.

86. The emulsion may be applied to the plants by pressure sprays fitted to the mechanical cultivators, and a large acreage can thus be covered each day. Even greater areas can be treated with the latest 50 ft. boom sprayers operating from the terrace roads, and covering the whole of the 21 beds of each block in two straight runs.

87. These boom sprayers, which have been evolved by plantation engineers, can be used to spray not only diesel oil but also mealy bug mixtures, liquid fertilisers, ferrous sulphate solution and hormones. Details of construction may differ but the principle of their design is the same. They consist of a heavy lorry, a tank, and a stainless steel pipeline carried by a stainless steel boom, extending at right angles from the side of the vehicle. The pipeline is fitted with about 60 fixed, oscillating, rotating or swirling nozzles arranged at fixed intervals and ensuring excellent coverage. Owing to the corrosive nature of the solutions used, it is necessary to paint the metal work of the lorry with an asphalt paint.

Fertilisers.

88. In the early days of the industry the pineapple was considered a very exhausting crop since lands repeatedly cultivated with this crop, without any system of crop rotation, yielded plants which were small, yellow and withered, and which easily succumbed to pests and

* HARROWING AND FERTILISING.

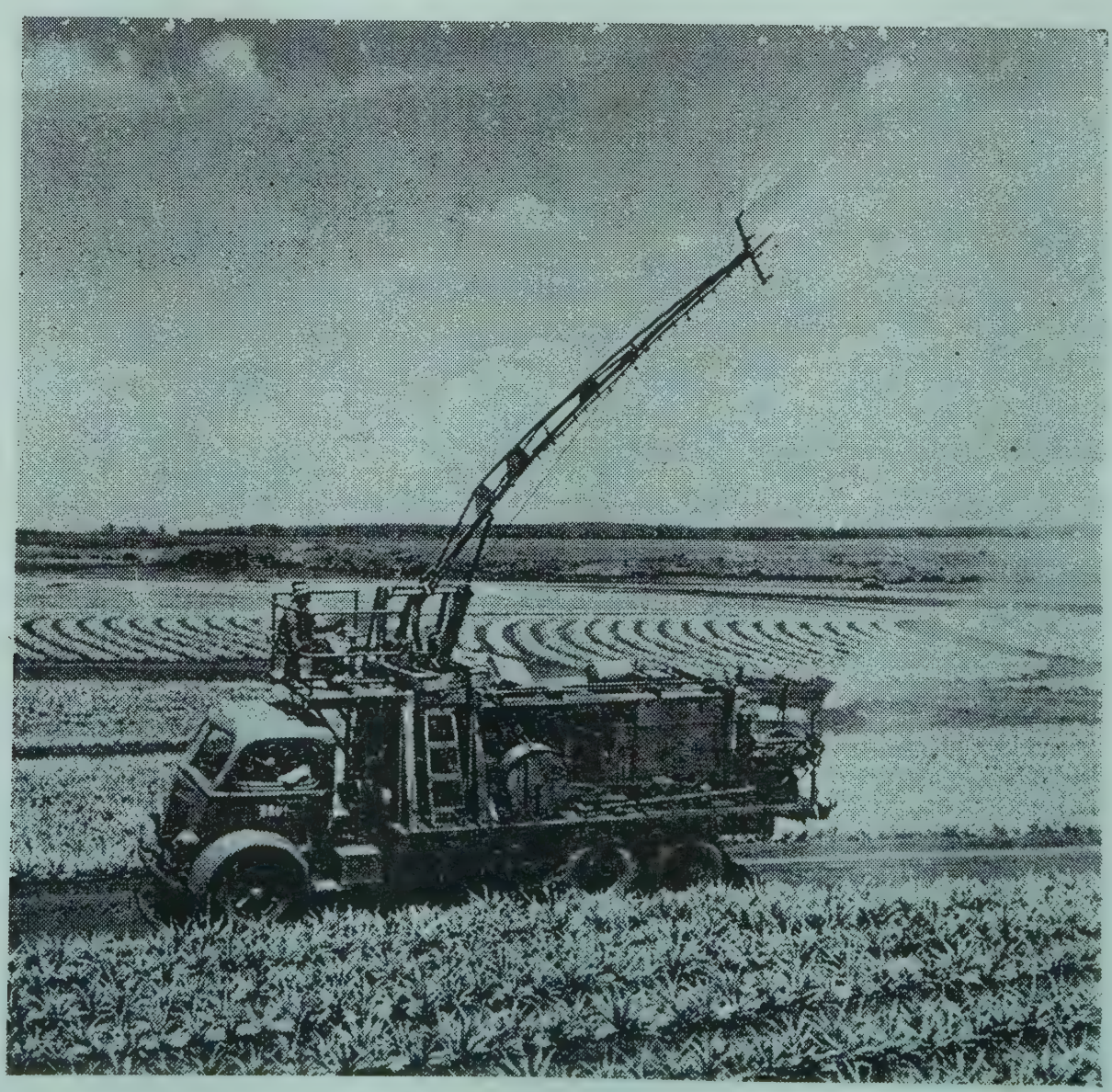
A mechanical cultivator fitted with twin delivery tubes for applying fertiliser. The triple hoes loosen the soil in the plant lanes.

A FIELD OF YOUNG PINEAPPLES.

The exactly parallel rows make it possible to lay a ribbon of fertiliser along the lines of plants.

* HARROWING AND OILING.

A mechanical cultivator fitted with sprays is used to kill the weeds in the plant lanes between the mature plants.



* IRON SPRAYING.

Plants are sprayed with ferrous sulphate solution at intervals throughout their growth. The iron is absorbed through the leaves.

diseases. To overcome this, it was considered essential for the permanence of the industry to adopt a system of shifting cultivation with continuous progression on to virgin lands.

89. To-day there is an entirely different attitude of mind:—"Anyone can grow pineapples successfully on virgin land, but it requires real knowledge to plant pineapples repeatedly and successfully on the same piece of land". As a result, there are lands which have been planted again and again with pineapples, without resting, and without any system of crop rotation, even for as long as 40 years.

90. The preliminary treatment of the soil, before and in the 6 months immediately after planting, is considered a very important factor in deciding the quality of the crop; but with repeated plantings of a single crop, mineral deficiencies are also bound to develop in the soil and must be corrected.

91. Chlorosis, indicated by overall yellowing of the leaves, is an indication of such deficiencies and of a probable lack of photo-synthetic activity in consequence. It may be due to lack of available iron in the soil which can be proved at once by the application of ferrous sulphate directly to the leaves which quickly turn green if there is any deficiency of this mineral. If not, the relative degree of yellowing is a measure of the need for nitrogen, whilst yellow mottling (in the absence of mealy bugs) is regarded as an indication of zinc deficiency.

92. While nitrogen is the principal and universal requirement, in some districts potash and phosphorus are also important deficiencies. Considerable emphasis was laid on the importance of maintaining the same potash-phosphorus ratio in the soil as in healthy leaves (*viz.* 12:1), since it is said that if too much phosphorus is added, the nitrogen intake is upset and the result is a reduction in the yield of fruit.

93. Hawaiian pineapple soils are rich in iron, but little of it is in a form in which it can be taken up by the plants. It is either in the ferric state or associated with manganese, and as such is not available as a plant nutrient. The discovery that pineapples need a trace of iron and that ferrous sulphate can be absorbed through the leaves made it possible

to grow pineapples on lands which were previously regarded as unsuitable. Zinc may also have to be applied in trace amounts to prevent crop failure on exhausted lands which have been repeatedly planted with pineapples; there has also been a response to traces of boron.

94. Any mineral deficiencies have to be corrected before the plant is due to bud. The fertiliser programme for every individual block is based on various plant studies and on the analysis of leaf bases (not of the soil) collected from the block during the period 2 to 5 months after planting and while the plants are establishing themselves. Fertilisers are usually applied between 9 and 12 months after planting, or earlier if the results of analysis indicate that the mineral deficiency is serious.

95. On every plantation there is an installation for the preparation of various chemical solutions (for use in the mechanical sprayers) consisting of an arrangement of stainless steel screens, stirring and blending tanks, and inter-connected stainless steel piping of large bore, delivering to a number of 6 ins. slosh valves which ensure a quick fill-up for the mechanical sprayers or tank lorries.

96. Ammonium sulphate and potassium sulphate may be dissolved, blended and applied together in liquid form using the boom sprayer, or they may be applied in powdered form directly to the base of the plants. The machine used in this case is the mechanical cultivator specially fitted with twin hoppers to contain the fertiliser. As the machine advances along a bed of pineapples, with its wheels in the plant lanes, the leaves of the plants on either side are gently brushed aside by the fertiliser tubes and a ribbon of fertiliser is dropped along the line of plants, quite close to the base of each plant, while the set of hoes behind the wheels loosens the ground again after the vehicle has passed.

97. During the war ferrous sulphate for use as an iron spray was obtained by dissolving scrap iron in sulphuric acid. The resulting green crystals were dissolved in water in the ratio of 1lb. in 7 gallons of water (1 in 70), and sprayed at high pressure as a fine mist, high over the plants, from a tower sprayer, mounted on a moving tank-lorry, which followed the terrace roads and so covered all the plants quickly and efficiently. The rate of application is from 10 to 15 lbs. per acre.

PLATE 7.

* THE MEALY BUG.

The pineapple mealy bug has an ant attendant which protects it from lady birds and moves it from plant to plant.

PLATE 8.

PINEAPPLE WILT.

The mealy bug is the cause of pineapple wilt. The leaves wither and the plants become non-yielding, or else produce small woody fruits.

Pest Control.

98. The major biological problem in Hawaii is the quick wilting of large healthy plants due to a toxin introduced by the mealy-bug, a small helpless louse-like creature, which acts as the "milch cow" for the common Aphis ant which carries it into the pineapple fields and protects it from attack by lady-birds. The mealy bugs attack the underside of pineapple leaves, pierce the epidermis, suck out the juices and inject a toxin brought from an adjacent diseased plant. The ant is fed by a sugary exudation from the mealy-bug, and so the presence of an ant on a plant is a fair indication that there is mealy-bug infestation which can be confirmed by examining the underside of the leaves. The mealy bug does not remain on an affected plant but is moved on by the ant and so the disease spreads in ever-extending patches until the whole field is affected.

99. The mealy bug has been shown by Carter to be the agent primarily responsible for the widespread destruction of pineapple plants. The disease is said to assume several forms, depending on the source of the mealy bugs, on the severity of the attack and on the vigour and succulence of the host plants. It is less severe on virgin lands, and recovery may sometimes occur, but the fruits, though otherwise normal, are small.

100. This wilt, which is the result of progressive root decay, takes place in four stages. Green-spotting of pineapple leaves is a localised effect at the insects' feeding point and is not a wilt symptom. The first symptom is a change in the colour of the leaves which become reddish yellow. In the second stage, the leaves commence to wither at the tips; in the third stage the shrinkage of the leaf develops downwards and the dry part droops; finally in the fourth stage there occurs the total collapse of the leaves of the plant. If any fruits at all are obtained from such plants they are usually small, shrunken, and woody due to the drying up of the peduncles.

101. In the first cycle of a virgin field, mealy bug wilt is always negligible but, with repeated plantings with the same crop, the menace grows. Plants may yield fruits of fair size in the plant or first crop, but the following ratoon crops are total failures, the first ratoon crop being reduced from a possible 35 tons to 3 tons or less per acre. For this reason mealy-bug control is the basic operation in pineapple

cultivation in Hawaii, since the Cayenne pineapple has been found to be the most susceptible of all varieties to this disease which at one time threatened the extinction of the industry.

102. Careful selection of planting material to exclude slips from diseased plants is a first essential in the control of wilt (see para. 67) ; the second is repeated ploughing of the land during the inter-cycle period to reduce the ant population before planting (see para. 48) ; and the third and most important of all is to attack both partners of this association with insecticides.

103. When the field is being prepared for planting, the soil is sprayed to rid it of ants, since the mealy-bug is helpless without its ant attendant. Subsequently, after the field has been planted, fresh invasions occur on the borders of the field and spread rapidly inwards, so a guard ring extending right round the field is established to protect the main crop.

104. It has been noticed that mealy-bug advance is more rapid along the rows than across the rows, so the guard-ring consists of six continuous beds of pineapples set across the line of advance of the mealy-bugs. Standard practice is to treat the growing plants within this ring with a single blanket of spray, and to spray the guard ring intensively once a month by means of a boom sprayer which follows the inner encircling road. If border leaks are detected by the pest locaters, the spot is intensively sprayed.

105. The basis of the mixture used in the sprayers is diesel-oil, modified and emulsified by Bentonite. The actual insecticide to be added has not been finally settled. At present, up to blossoming, D. D. T. is first favourite, but as this does not provide total protection by complete elimination of the pests the search for the perfect insecticide is being continued. The D. D. T. destroys the ants, while the oil primarily attacks the mealy-bugs.

106. Until recently, emulsions containing 2 lbs. of D. D. T. in 1,000 gallons of water were applied at the rate of 1,000 gallons per acre, but it has since been found much more economical and as effective to use very much stronger emulsions and to apply them less heavily since this saves time, results in greater coverage per day, and so needs fewer boom sprayers to cover the same acreage. The rate often used is 350 gallons per acre of a 12 per cent. solution.

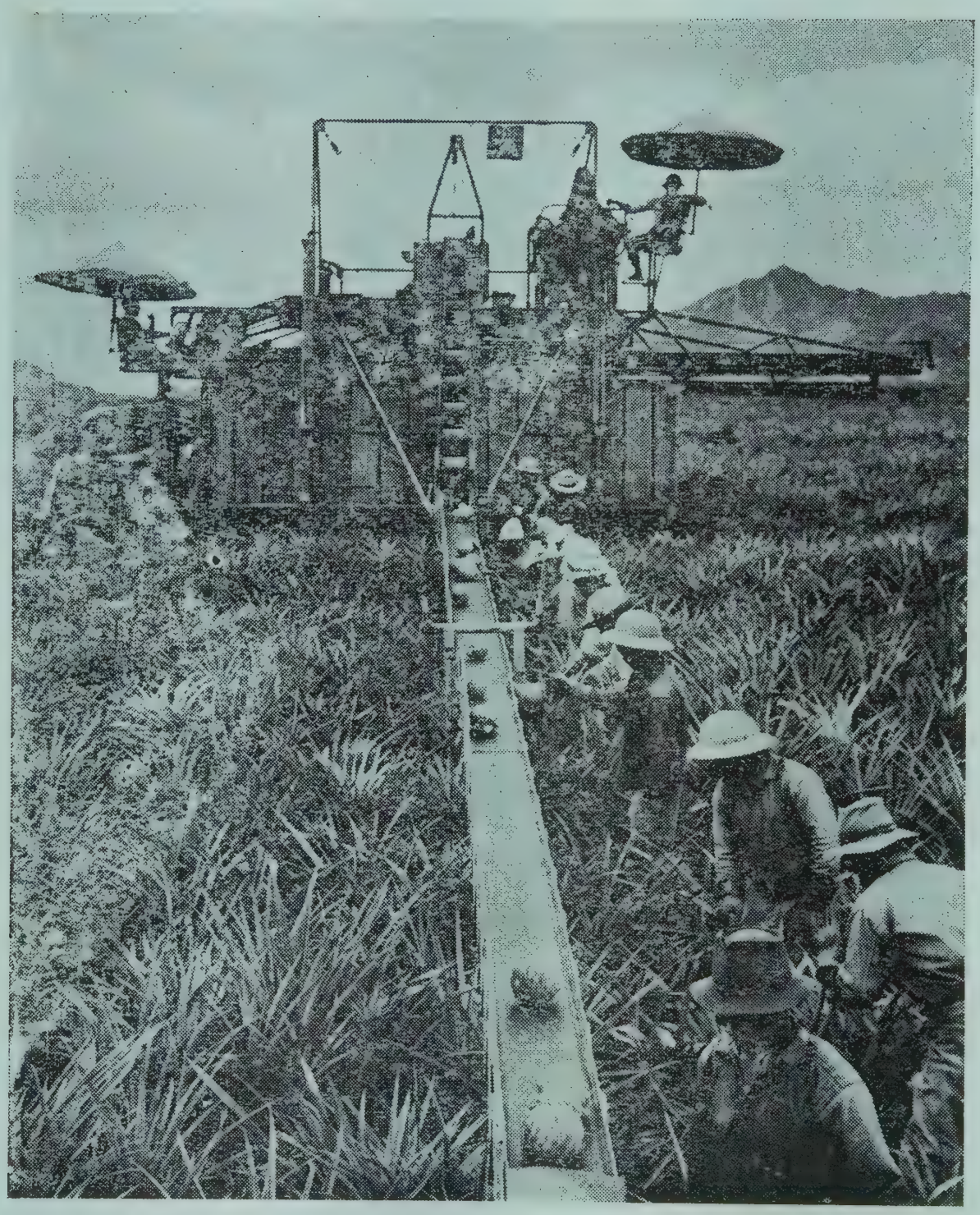
*** PEST CONTROL.**

A guard-ring of six continuous parallel rows of pineapples borders every plantation. This is intensely sprayed with insecticide at regular intervals.

*** PEST CONTROL.**

A mechanical boom sprayer is used to apply a mixture of diesel oil and D.D.T. to destroy the ants and mealy bugs.

PLATE 10.



* HARVESTING.

On this plantation the pickers walk behind a 50 foot conveyor belt boom which delivers the fruits into a double-tiered bin. When it is full, four jacks lift the harvester and the lorry drives away.

The Harvest.

107. The normal practice is to work individual fields on a 4 year cycle, as follows:—

1st year	..	Preparation and planting.
2nd „	..	Cultivation and plant growth.
3rd „	..	Harvesting (plant crop).
4th „	..	Harvesting (ratoon crop).

Thus at any time, while one half of the total acreage is being prepared, planted and developed, the remainder is bearing fruit. Only in exceptional cases and in certain areas is a second ratoon crop worth harvesting so that a 5 year cycle can be operated.

108. The gross yield of fruit for the full cycle of 4 or 5 years from individual fields varies between 40 and 70 tons of fruit per acre, but for the whole planted acreage under pineapples in Hawaii, the overall annual yield is estimated to be between 12 and 13 tons per acre.

109. The first or plant crop is between 25 and 35 tons per acre, the second or first ratoon crop between 20 and 25 tons per acre, and the third or second ratoon crop ranges from nothing up to 15 tons per acre. Formerly, crops were considered satisfactory if the plant crop produced 7½ to 10 tons, the first ratoon 5 to 6 tons, and the second ratoon 2 to 3 tons per acre. For a 5 year cycle, this is equivalent to only 3 tons per acre per annum. Thus, even after repeated cultivation as a sole crop, the annual harvest has, as a result of improved field practice, been more than quadrupled.

110. The plant crop consists of large fruits, weighing between 3 and 6 lbs., the first ratoon crop consists of small sweet fruits, weighing between 2 and 4 lbs., and the second ratoon fruits are of luscious flavour but very small in size and generally less than 2 lbs. in weight. The overall average fruit weight is 3½ lbs.

111. The quality of the fruit also varies seasonally. There is a striking difference in the quality of ripe fruit picked at the height of the season in the summer and in that of ripe fruit picked in the winter or off-season. The summer fruit is sweeter, less acid and more fruity in smell and flavour than the winter fruit to which, in consequence, extra sugar has to be added when it is canned.

112. In an attempt to obtain maximum sugar development and reduce the acidity of winter fruit, it is purposely left longer on the plant, but this causes the fruit to soften,

and there is greater liability to bruising. Were summer fruit left on as long, its acidity would become too low and the flavour would be flat and insipid!

113. Fruit is collected and canned as it becomes available at any time of the year, but the bulk of the crop, and the best fruit, is harvested in the peak period, June to August. On one plantation the following is the operational record of a year's harvesting:—

	Days.		Days.
January ..		July ..	24-27
February ..	7-15	August ..	15-21
March ..		September ..	4
April ..	2-3	October ..	2-3
May ..		November ..	
June ..	4-5	December ..	16

Although the total number of harvesting days per year is ninety, 85 per cent. of the crop is collected in 45 days, during which period work goes on day and night.

114. The June crop is the result of the spring planting with suckers; the heavy July-August crop is obtained from the autumn planting with slips; and the winter or off-season plantings yield fruit irregularly in small quantities in any month of the year. Ideal results are, as previously stated, only to be obtained from the autumn plantings.

The First Ratoon.

115. The mother plant is pruned after the plant crop has been collected, the slips are all removed and one or two suckers only are left to produce the ratoon crop. More often however the plant is left to ratoon freely. The suckers establish themselves and produce the second crop a year later.

116. The first ratooning operation is fertilising, usually in May, shortly before the first or plant crop is harvested. This serves to stimulate the growth of slips and suckers and also, unfortunately, to promote weed growth which at this stage has to be controlled entirely by hand-hoeing or not at all, because, if a hoeing machine entered the plant lanes the suckers would be damaged. Iron spraying follows fertilising and weeding.

The Second Ratoon.

117. Occasionally when the stand of plants is sufficiently vigorous a third (or second ratoon) crop can be harvested. By this time the identity of the rows has

practically disappeared, owing to overcrowding and uncontrolled weed-growth, and the plants are affected by wilt. Generally the second ratoon crop has to be hand-harvested as the progress of the pickers is too slow and irregular for mechanical harvesting.

The Use of Hormones.

118. The ratoon crop matures with less regularity than the plant crop and harvesting is consequently spread over a longer period of time. Some fruit matures after the pickers have made their round and becomes overripe before the next round. In any case the pickers have to revisit the same area repeatedly, so increasing the cost of collection.

119. By the use of one of the hormones, the new chemical growth-promoting substances, harvesting of the ratoon crop can now be concentrated into two months instead of six, and, by working to a time-table and applying the hormone to various blocks in turn, it is possible to harvest these in succession during the best ripening months. The resulting crop is large because every sucker head is forced to fruit and because no incipient bud fails to develop.

120. The hormone used, known as ANA*, is applied in extremely low concentrations (about 3 parts per million of water) by boom sprayers operating from the roads. It is applied just before the buds are formed, and it forces all backward flowers to set so that all the fruit develops and ripens simultaneously.

121. In doing this, the nature of the plant is changed. Plant reserves are drawn upon to encourage fruiting at the expense of vegetative growth, and, in consequence, sucker development is reduced and there are no basal slips. This non-production of slips is one reason why this hormone is not generally applied to the plant crop, but in addition the ratoon crop would be reduced. Another hormone, described as BNA †, is used to strengthen the stem, enlarge the fruit and give it a firm (i.e. not spongy) texture.

122. The hormone 2-4 D ‡ and a number of others are used in higher concentrations to destroy incipient weed-growths when the ground is bare of pineapples, while 2-5 T is used to collapse and destroy a worn-out ratoon crop before replanting. This hormone has a remarkable stimulating

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* ANA = Alpha Naphathalene acetic acid.
† BNA = Beta Naphathalene acetic acid.
‡ 2-4 D = 2.4 dichlor phenoxy acetic acid.

effect on the growth of broad-leaved plants and, applied to the stem and leaves as a rain of spray, it swiftly brings about fatal acceleration of plant processes and early death. Light has been found to increase its effect which is most marked on young plants.

123. The success of a crop, as previously stated, is determined by the incidence of sunshine and rainfall during the life of a plant. Certain other hormones can be applied to off-season plantings either to speed up or to retard growth to fit in with the seasons in order to obtain improved yields and better fruit and also to concentrates the harvest into the four or five best months of the year.

124. In hilly areas (above 2,000 ft.), plant disease occurs in young plants due to a soil fungus which is most active in cold, wet weather. In consequence normal summer plantings are a failure owing to the succeeding rains, and spring planting is thus essential.

125. There are many hormones. Some quite unsuitable, some too dangerous to use, and some quite unpredictable in their behaviour. Extreme caution has to be exercised in investigating them and in recommending their use. No information was obtained regarding the effect of hormones on the chemical composition of the flesh of the fruit.

Harvesting the Crop.

126. In Hawaii, the very marked seasonal peak makes the summer harvesting of these big crops a period of continual stress and strain to ensure that there are no losses through delays in collection, transportation, or unnecessary storage. At this time of the year the fruit quickly passes from a ripe into an overripe condition; fermentation sets in and the fruit develops an offensive flavour and becomes soft and useless.

127. During this peak period the same field is visited at fortnightly intervals and harvesting goes on day and night. The war brought an acute shortage of labour and resulted in the wide-spread use of mechanical aids and in the entry into the industry of high-school and college students on vacation and married women to assist in bringing in the harvest at the height of the season.

128. The picking gangs proceed down the plant lanes picking the fruits with proper discrimination, since unripe Cayenne fruits do not improve in storage after they have

PLATE 11.

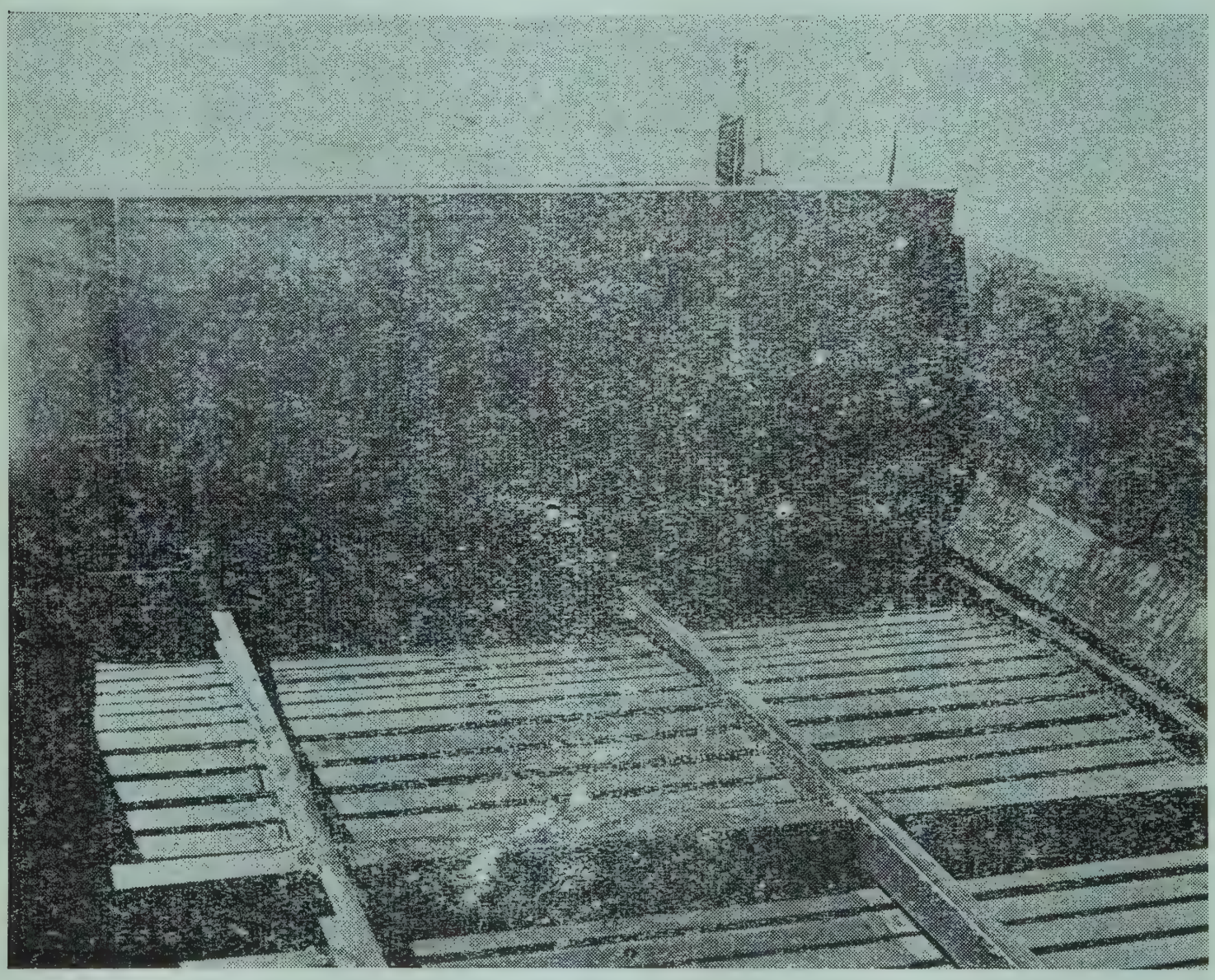
* HARVESTING.

Here the pickers put the fruit into shoulder slings and deliver their loads to an escalator lorry.

TRANSPORTING THE FRUIT.

The escalator lorry is fitted with a detachable fruit elevator and has a moving floor which receives the fruit and moves as the lorry fills up.

PLATE 12.



THE ESCALATOR LORRY.

An interior view of the escalator lorry with the rear escalator removed. The moving floor and the moving end are in the 'empty' position.

been cut. Colour is not always taken as an indication of ripening, particularly in the wetter, less well-drained fields where the fruit may be ripe inside although the skin may still be green. Elsewhere the fruit is not ripe until the skin is completely yellow.

129. The pickers wear stout leather gauntlets with which they grip the crown of the fruit, give it a twist and a bend, and snap it off from the stalk, close to its base; then, grasping the fruit in one hand, they punch off the crown with the other. Thereafter there are three methods of handling the crop:—

(*a*) by means of shoulder-straps and lug-boxes.

(*b*) by means of shoulder-straps and escalator-lorries

(*c*) by means of the boom harvester.

130. When shoulder-straps are used, the fruits are put into light cloth slings with a capacity of about 100 lbs., or 20 to 25 fruits. This load is taken, sometimes quite a distance, to the nearest road-side, where it is either dumped into heaps and later packed into lug-boxes, or else it is emptied into the boot of an escalator lorry.

(*a*) *The Lug-Box.*

131. These boxes are of plain construction, 22 ins. long, 16 ins. wide and 13 ins. high; they take between 12 and 15 fruits each, and make a convenient load for lifting up on to the field lorries. Wear and tear is such that a plantation of 27,000 acres requires 100,000 new lug-boxes, valued at $140,000, every year.

132. The boxes, when full, are lifted up and stacked, one on top of the other, on the lorries and taken a short distance either to the nearest railway or wharf for dispatch to the canneries. This involves three human lifts and much walking under load; furthermore bruising occurs if the fruit overtops the boxes, and it becomes more serious owing to delays and vibration in transit. The lug-boxes are a great nuisance as the requirements in the field are difficult to estimate; there may be too many or too few, resulting either in needless work or idle time.

(*b*) *The Escalator-Lorry.*

133. This is now being increasingly employed to replace the use of lug-boxes where the cannery is in or near the pineapple fields, and in hilly areas where it is not

practicable to use the boom harvester. The escalator-lorry, invented in 1942, is an ordinary lorry, fitted with a slat elevator, a moving floor and a moving end, all operated mechanically by the engine of the vehicle through a system of pulleys, chains and gears. The slat elevator can be detached from a full lorry in a few seconds and transferred to an empty lorry.

134. The working team of pickers which accompanies the lorry is from 10 to 16 men, depending on the crop. The line of pickers, equipped with shoulder straps, advances down the lanes at a steady rate picking the fruit while the lorry moves along the adjacent terrace-road at about one mile per hour.

135. As each man fills his sling he leaves his lane, takes his load to the lorry and rolls it gently into the boot of the slat elevator which is arranged at just the right level. (Formerly this load was dropped onto the ground). The fruit is raised about 4 ft., and at first drops 2 ft. on to the slatted floor of the lorry, but after this it merely rolls to rest on top of the fruit already in the lorry. As the space fills up, the slat conveyor, forming the floor of the lorry, is moved gradually to make room for more fruit. The watching attendant does not stand or sit on the fruit but sits on a special seat which is provided.

(c) The Boom-Harvester.

136. After the Ginaca machine (see "peeling and coring"), perhaps the most remarkable invention, developed in Hawaii, is the mechanical harvester. It made its first appearance in 1946, and within a year every plantation in the Islands was equipped with one or more of these complicated machines. The largest plantation has no less than forty of them, all designed and assembled by their own engineers in their own work-shops. In the peak of the season these machines operate day and night and lights are fitted to the boom at the proper intervals to cover each of the plant lanes.

137. The machine is simply a portable fruit conveyor and elevator. It has a long conveyor arm which reaches out over ten beds of pineapples so that the pickers no longer have to walk to the road-side under load but have only to pick the fruit, knock the crowns off and place them on the moving belt which advances before them as they progress down the lanes.

138. Each plantation has evolved its own type of boom harvester. The booms are adjustable to allow for differences in slope and for ease in turning the machine; some booms are fixed and some can be rotated through a half-circle; some deliver the fruit into lorries, others deliver it into bins. Most of them move under their own power, but one type depends, for its forward movement, on a lorry which drives in under the harvester with an empty bin while the harvesting machine is raised and then lowered again by four hydraulic jacks. When the bin is full of fruit the machine is again lifted, the lorry, with its bin, drives away, and another lorry, with an empty bin, follows in behind and takes its place, and harvesting is again resumed after only a short delay.

139. The field lorry, with its full bin, proceeds to the loading station where it is straddled by an immense Ross lumber jack which lifts the crate off and transfers it to a heavy trailer which takes two full bins (16 tons of fruit) by main road to the cannery in Honolulu. Alternatively, where sea transport is necessary, the field lorry proceeds to the wharf, where large cranes lift the bin and deposit it on to a 1,000 ton barge which, when full, is towed away to Honolulu, 80 miles away, by Diesel-electric tug. There is a special system for mooring these barges which prevents damage to the fruit through the surging of the sea.

140. In the peak of the season, when all the harvesters are in operation, central control is established on a tower on a high point to direct by telephone the returning field lorries to where they are needed so that the harvesters can all be kept in continuous operation and there is no idle time. This is essential since 600 bins, equal to 4,000 tons of fruit, have to be collected each day from 15,000 acres during this rush period.

141. The bins have a heavy angle-iron framework, fitted with ring bolts, and are made of medium heavy timber. They are hollow-walled so that the surfaces, both internally and externally, are smooth to ensure that the fruit can be ejected smoothly and the bins can be snugly packed on the decks of the barges. They each weigh about 1 ton when empty and are approximately 15 ft. long, 4½ ft. broad and 4½ ft. high. They will carry about 7 tons (4,500 fruits) each.

142. The shell of the Cayenne pine is thin, not mechanically strong and bruises easily; just over 2 ft. is

regarded as the maximum of fruit in the bins if there is not to be serious damage through crushing in transit. For this reason, these bins are divided into two tiers by a collapsible floor which can be folded back against the sides while the bottom half is being filled. At the ends of the bins there are two quick-release doors through which the fruit is gently rolled out when the load arrives at the cannery.

143. The largest plantation with about forty of these machines has spent about $2,000,000 on harvesters and a further $1,500,000 on bins to carry the fruit.

Damage to Fruit in Transit.

144. To insure the finest quality of canned pineapple, the fruit is allowed to ripen on the plant. This demands that the fruits must be handled with care, transported with speed, and processed rapidly and expeditiously.

145. With the boom harvester the fruit is never handled again after is has been cut and placed on the boom conveyor. It is never dropped, thrown, trodden on or otherwise mishandled, and all subsequent movement is by rolling or mechanical conveyance. In spite of this about 25 per cent. of the fruit still arrives very slightly bruised and 1 per cent. is severely bruised. Bruise spots are cut out at the trimming tables and sent to produce juice.

146. The total time that elapses between harvesting the fruit in the field and cutting it in the factory is normally 24 hours, with an outside limit of 48 hours. Exceptionally, as for instance through a strike or breakdown, there may be delays, but if the fruit is kept longer than 3 days it is useless and has to be dumped into the sea.

MECHANIZATION IN THE FIELD.

147. The extensive mechanization of plantation operations in the Islands was in the first instance the direct result of acute labour shortage during the war. To-day, the extremely high wages demanded by labour is intensifying the need for the further introduction of new machines wherever possible; out-moded machines, still in good mechanical condition, are having to be ruthlessly scrapped and replaced by machines of greater efficiency and output.

148. Before the war almost all field operations, except ploughing, were carried out by draught mules or by hand labour. Now road-making and terracing, knocking-down,

harrowing, repeated ploughings, paper laying, weed destruction, soil fumigation, harvesting and the application of fertilisers, hormones and pest sprays, all major operations, are done by machines. Only one serious item in the cost of production remains to be mechanised, that is the planting of the slips, and it is hoped to incorporate even this into the paper-laying machine. The plucking of the fruit, the collection and stacking of planting material, and hoeing and weeding the ratoon crops, are also operations which have still to be done by hand labour and cannot possibly be mechanised, but it is fair to claim that the plantation side of the industry is about 90 per cent. mechanised.

149. In 1929 the wage paid was 34 cents per hour; the corresponding minimum wage today is $2.02 per hour for the simplest field work and this has demanded a 6:1 reduction in the labour required for the same amount of work. It was stated by one manager that it is now worth spending $4,000 in capital expenditure to save one man, and it was considered that, in any country where wages are in excess of 50 cents per hour, it is worthwhile introducing machines, more particularly where individual output is inadequate or the quality of the work is erratic or not of a high standard.

150. The machine, of course, does not always do the work as thoroughly as a conscientious man. For instance, it is certainly less wasteful and rather more effective to apply solid fertiliser by hand to the base of each plant in turn at the rate of well under 50 plants per minute than it is to put down a ribbon of fertiliser by mechanical means at the base of two lines of plants simultaneously, but by this means it is possible to deal with well over 1,000 plants a minute. Similarly more thorough treatment is obtained by laboriously hand-spraying individual plants than by the use of the boom sprayer which can cover a whole block in two runs, and so treat over 3,000 a minute. But only where it is not practicable to use machines, is hand treatment still practised.

151. Hand labour is a brake on the steady growth and expansion of industry, and it is considered necessary to use labour-saving and labour-easing machines wherever possible, not merely to reduce costs but also to secure vastly increased production. Mechanization demands high pay for the operators of the machines, a skilled maintenance service and increased capital expenditure per acre, but there is better

control of operations with less supervision, a reduction in overheads on account of housing and welfare services, and a material reduction in production costs.

152. In consequence of mechanization the wages of plantation workers have now been graded in proportion to the skill, initiative, responsibility, experience, and the degree of education which the various operations demand. Thus first-class mechanics receive $3.50 per hour, and electricians, machinists, and drivers $2.90 per hour, whereas ordinary field labourers are paid $1.94 per hour for hoeing and weeding, and skilled planting hands the equivalent of about $2.30 per hour for piecework.

153. A rather astonishing thing about this intense mechanization is the fact that so many of the complicated machines used both in the field and in the factory have been originated, developed and built by plantation engineers in Hawaii. In the first instance this was due to the war because there was no shipping available and plant manufacturers in America were all busy on war contracts. Nevertheless it is still considered good policy by plantations to continue to assemble or build much of their own plant and machinery, using either steel cut to order, or improvising from the parts of surplus war vehicles.

154. The reasons given for this unusual degree of self-help are as follows:—

(I) The machines can be designed to meet their special requirements, and early delivery is assured with no dependence on outside interests.

(II) It is possible to introduce alterations and improvements immediately the need is indicated by practical experience, whereas mass production methods do not permit of frequent changes in design nor is there such close contact with the needs of the industry.

(III) Machines can often be built much more cheaply from materials obtained from surplus military stores.

(IV) Purchase from specialist plant manufacturers requires sanction for capital expenditure, whereas the cost of construction on the plantation can be treated as an operational charge.

Thus a man normally employed as a syrup-mixer may work as a pipe-fitter in the work-shops in the off-season.

155. However, specialists in plant manufacture are able to incorporate ideas gained from many other industries and can apply mass production methods. They claim that standard items of field and cannery equipment can be bought more cheaply from them, and that the cheaper costs of manufacture by plantation engineers does not always take into consideration the wages paid to field and cannery workers temporarily diverted to the machine shop.

156. An important feature in the design of equipment and machinery for dissolving, mixing, and spraying chemical solutions is the lavish application of stainless steel, which pays for itself in longer life and reduced cleaning costs. If stainless steel is used, it is only necessary to wash down the machines and clear jets and valves free of clogging sediments. Without this, two or three hours very thorough cleaning has to be done each day and there is rapid corrosion of the machine when it is not in operation.

SECTION C—CANNERY PRACTICE.

STREAM-LINED PRODUCTION.

157. Stream-lined production, or the continuous flow of work, is the keynote of production in Hawaii. Pineapples arriving from the field are delivered, without undue delay, to one of the reception points of the main conveyor system of the cannery. They are carried along and successively graded for size, washed and diverted to one of several processing lines arranged in parallel. They then pass on rapidly through a system of chutes, belts and conveyors, and are peeled, cored, topped and tailed; the resulting fruit cylinder is trimmed and sliced, and finally the slices are graded and put into cans. All this in the largest cannery takes just over one minute. In the next minute, the can of fruit is vacuumised and closed. Then, by cooking under pressure, the product is pasteurised in 8 minutes, and the process is completed by cooling the hot can for a further 5 minutes. Thus a single pineapple passes through the entire sequence of processing operations in about 15 minutes.

158. Fruit is fed into the canning line continuously, many thousands of pineapples are prepared and processed simultaneously, and the pineapple waste is continuously removed and treated at once. There is thus no accumulation of work at any stage of the process. This is necessary because in the height of the season 4¾ tons of fruit are delivered into the canning line, 2,833 fruits are being prepared, and 4,010 cans of pineapple are being processed every minute.

159. The record day's pack in this cannery was 5,600 tons of fruit. On this occasion 2,691,335 pineapples were converted into 120,000 cases (Malayan equivalent) of canned fruit and juice.

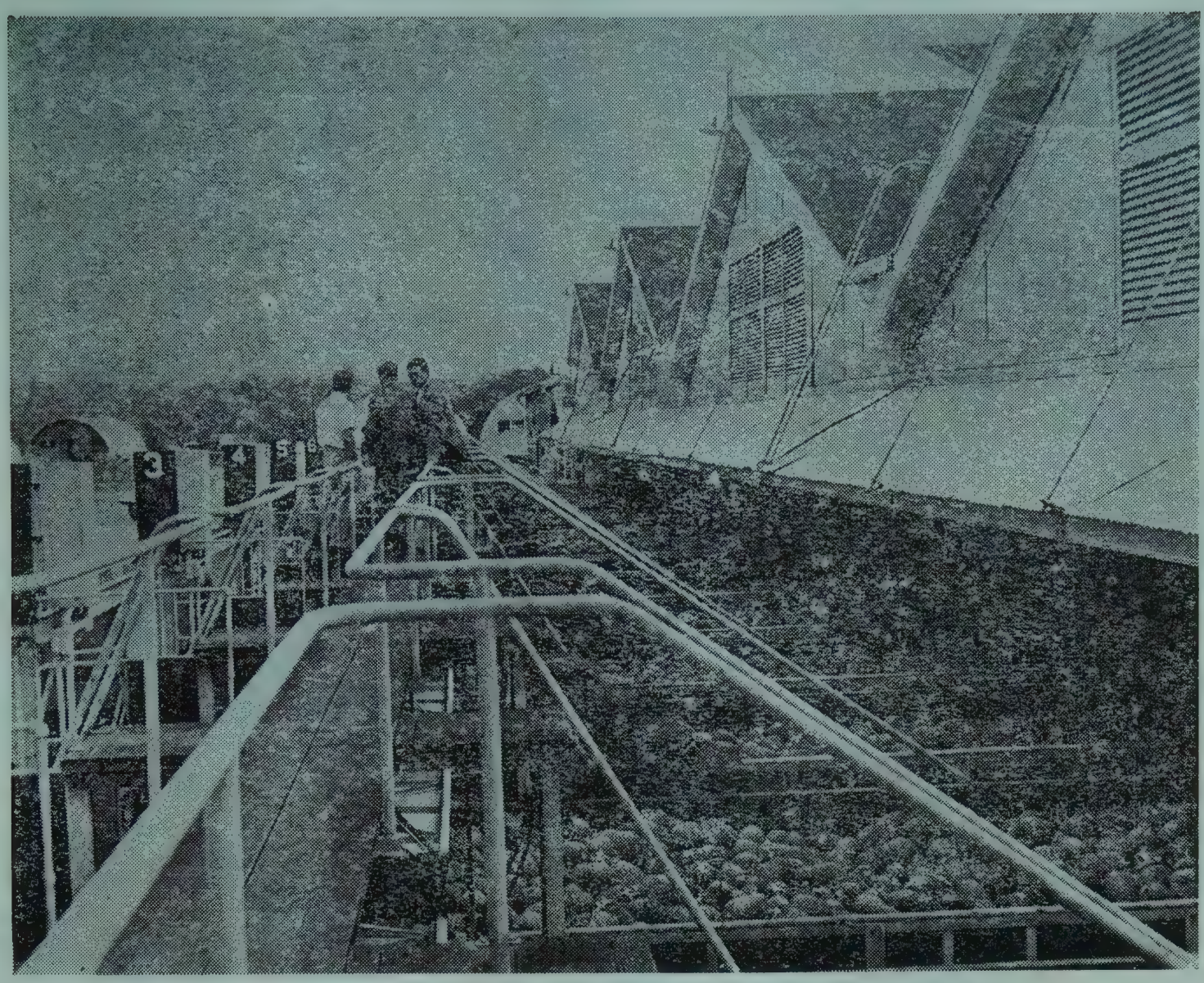
160. There are four separate and distinct stages in the canning process, *viz.* I. Fruit Preparation, II. Packing, III. Processing, and IV. Warehousing.

I. Fruit Preparation.

FRUIT RECEPTION.

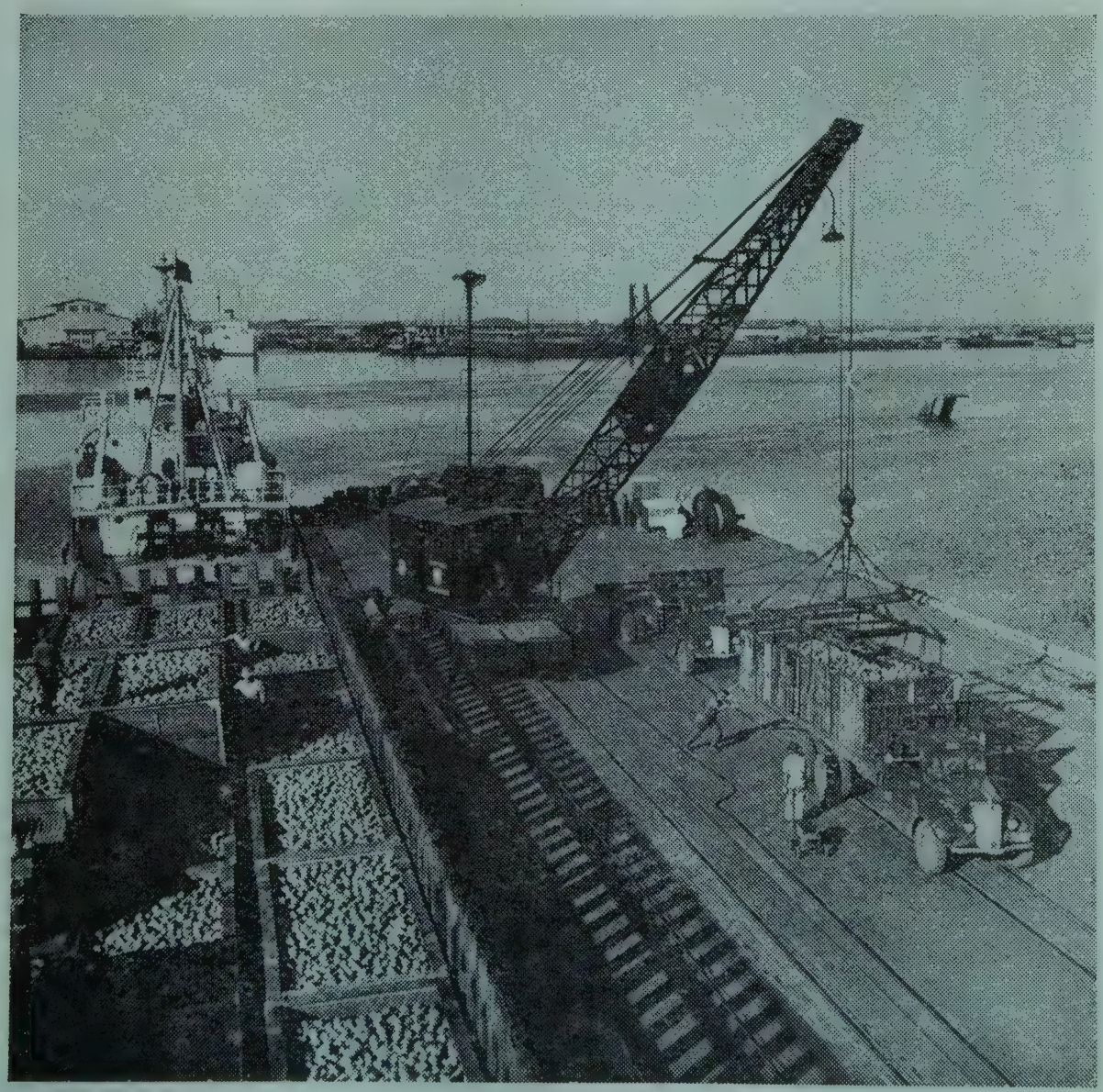
161. The three different systems of collecting and transporting the crop from the field, previously described, each require different methods of reception at the cannery. These are:—

PLATE 13.



FRUIT RECEPTION.

The escalator lorry delivers its load slowly into a fruit storage conveyor which holds the fruit till it is required. This shows a battery of storage-conveyors.



* FRUIT RECEPTION.

A barge load of full bins being unloaded at Honolulu. Each bin holds 7½ tons of fruit.

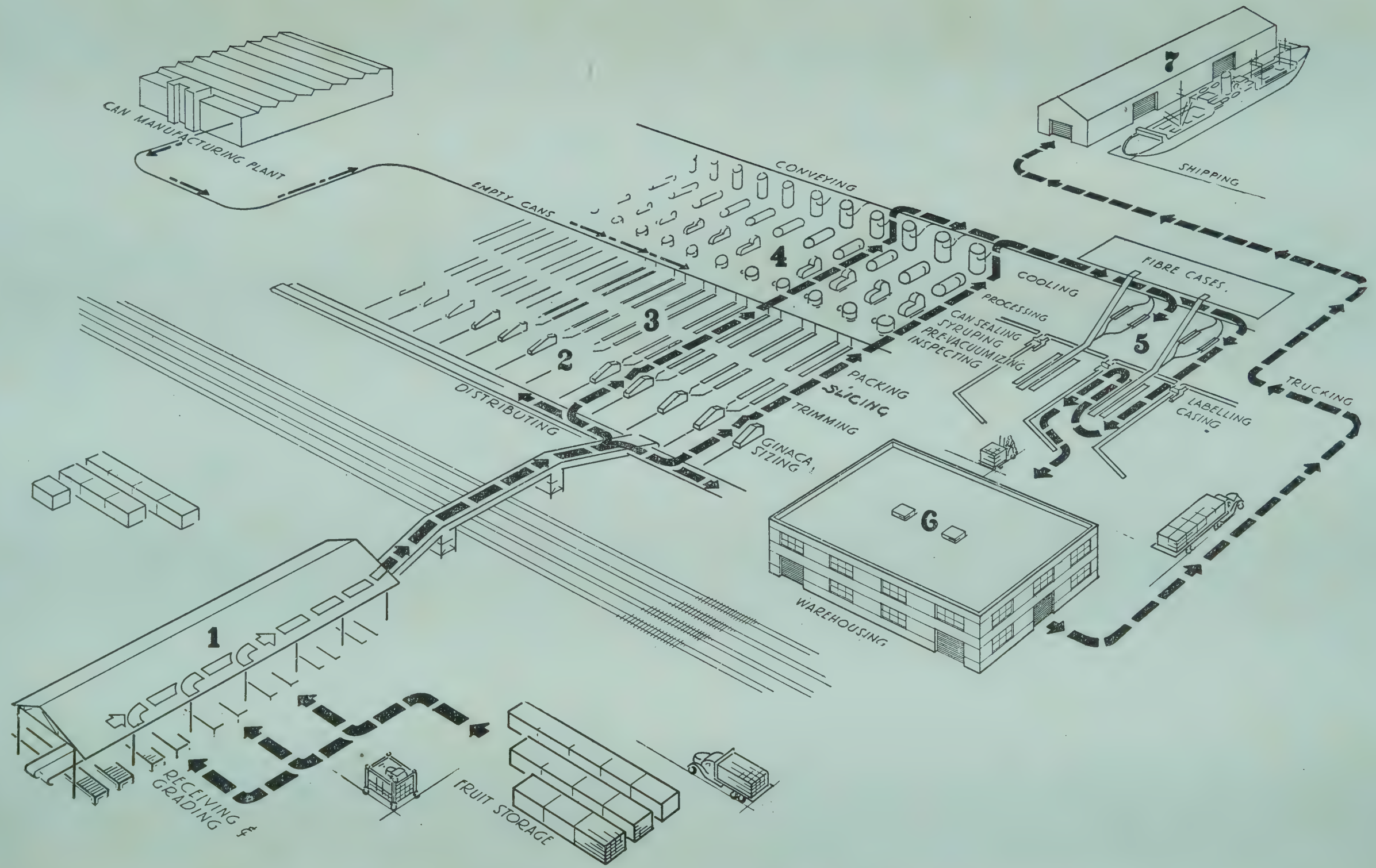


PLATE 14. * PINEAPPLE CANNING.

Diagram showing the reception, distribution and processing lines for the production of canned pineapple.

(*a*) Manual or semi-automatic ejection of the fruit from the small bins or lug-boxes.

(*b*) Mechanical delivery from the conveyor-fitted escalator lorries on to bulk storage conveyors.

(*c*) Hydraulic unloading of the large bins brought in from the boom harvesters.

(*a*) *Manual or Semi-automatic Ejection.*

162. The emptying of individual lug-boxes by two men directly on to the main conveyor belt of the cannery has now practically died out. The tilting ramp for mechanically emptying a stack of lug-boxes or bins of fruit which are moved in on wooden palettes by Clark finger-lifters (electric elevating and transporting trucks) is still being used in two factories. These tilting ramps are simply labour-easing devices which still require a large staff of men in attendance to operate the machines and remove the empties. The other out-of-date installations of this type are being replaced to save labour, to reduce the cost of production, and to substitute gentler methods of handling the fruit.

(*b*) *Conveyor-delivery.*

163. The escalator lorry, minus its rear elevator, brings its load of ripe fruit from the field right in to the cannery. On arrival the rear end is opened, the driver sets in motion the moving floor and the fruit is gently ejected on to a slat conveyor, 10 ft. wide and 100 ft. long.

164. This is known as a fruit storage conveyor. In one factory of medium size * there are twelve of these, arranged in parallel, and all delivering fruit on to the same main conveyor belt which carries the fruit into the cannery. Their purpose is simply fruit storage without dropping, crushing, throwing or manhandling the fruit unnecessarily and, between them, they carry a reserve of about 500 tons of fruit. The ripe fruits are gently rolled out of the lorries on to one of these storage conveyors, where they are stored without crushing, since the depth of fruit in the conveyors is only about 1 ft.

165. Any one of them can be operated individually by a single attendant from a central control tower at speeds varying between 3 ins. and 9 ins. a minute, or they can be

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* Output about 750,000 Malayan-size cases per annum.

stopped altogether. Thus during the peak season, 6 may be receiving fruit, 3 delivering and 3 waiting in reserve during the day; while at night 2 may be receiving fruit, with 7 waiting in reserve and 3 operating.

166. The change from tilting ramp delivery to storage-conveyor delivery has resulted in a staff reduction from 30 to 4 men and has entirely eliminated the heavy expense of the annual replacement of damaged lug-boxes which are so troublesome in the field and so damaging to the fruit.

(*c*) *Hydraulic-unloading.*

167. This is the method used in the largest cannery * which is organised to receive up to 5,000 tons of fruit a day and a peak load of 250 tons per hour. The ripe fruit is handled regularly and methodically without any shortages or gluts developing, and is processed without undue delay. Although a working reserve is held, fruit is neither accumulated nor stored.

168. When a trailer-truck arrives with its two bins of fruit, it is first registered and weighed. A Ross lumber-jack then straddles it and removes first one and then the other bin and places them next in line with two hundred other waiting bins, standing on dunnage in the fruit reception yard, providing a working reserve of 1,500 tons of fruit, awaiting treatment.

169. Meanwhile a second lumber-jack is lifting the bin that has been waiting longest and carries it to one of several reception points of the main conveyor system of the cannery. The bin is lowered on to the head of a hydraulic ram, the lumber-jack leaves, the quick-release gate of the top tier of the bin is opened and the fruit is gently and gradually ejected as the ram slowly rises and tilts the bin. When the top tier is empty the bin is raised 2 ft. so that the bottom tier can be emptied by again tilting the bin in the same way.

170. The empty bin is then shot forward on rollers, passes on right through the reception shed, is removed on the far side by a third Ross carrier, and placed in the empty bin yard to await its return to the field. By thus ensuring the continuous supply of full bins to reception points on one side of the reception shed, and their regular removal when empty, on the opposite side, traffic congestion and collisions are avoided during the peak rush.

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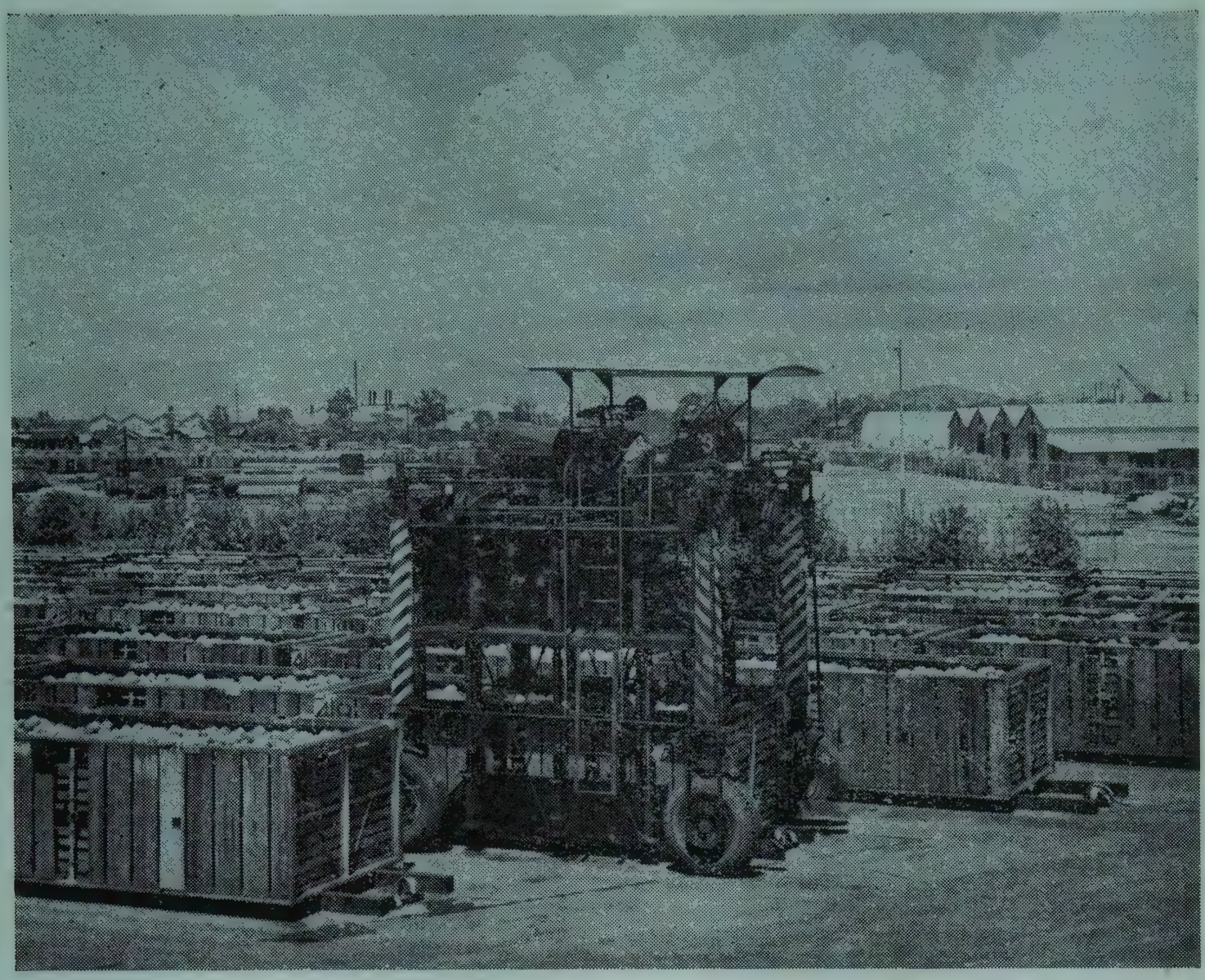
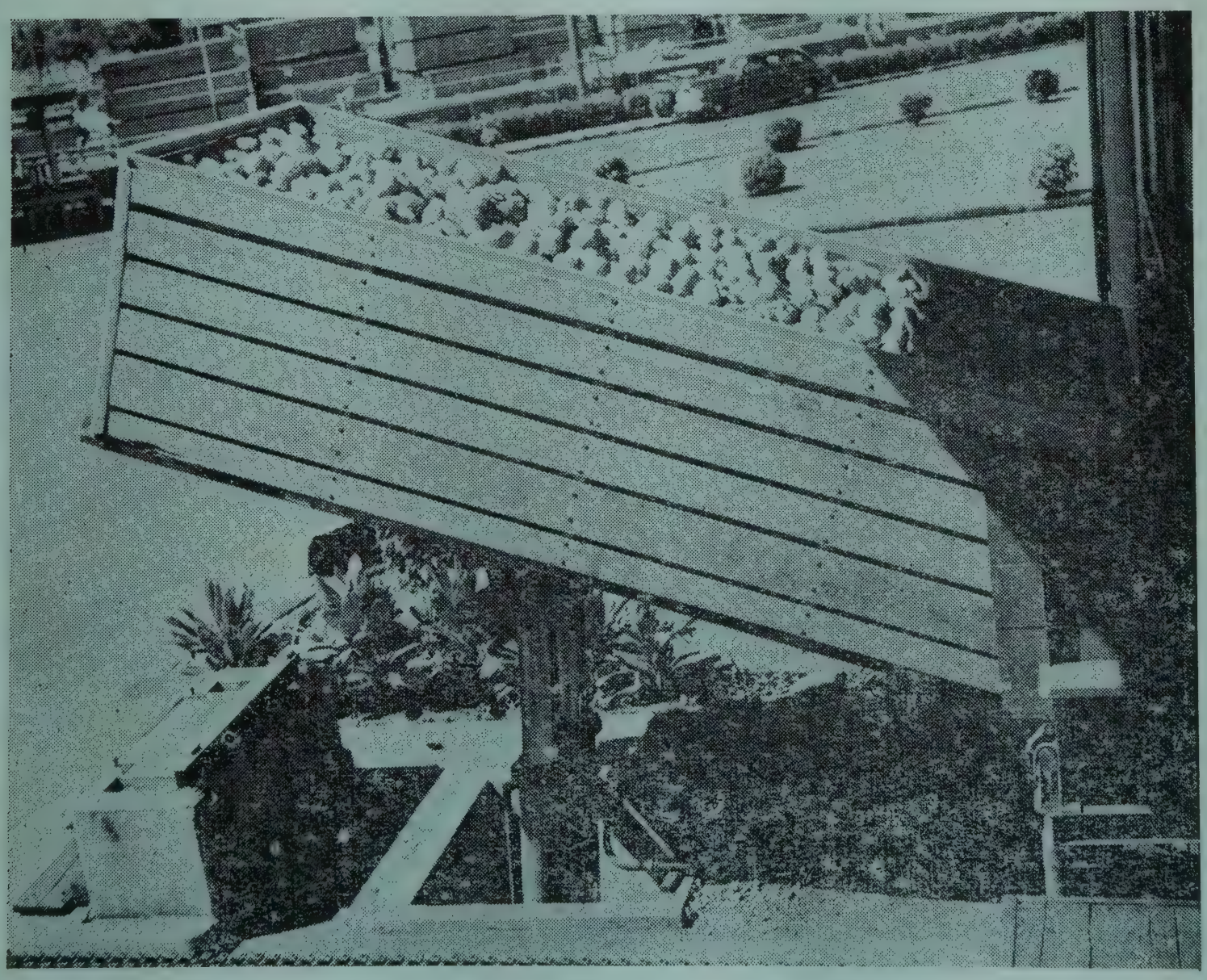
* Output about 4,000,000 Malayan-size cases per annum.



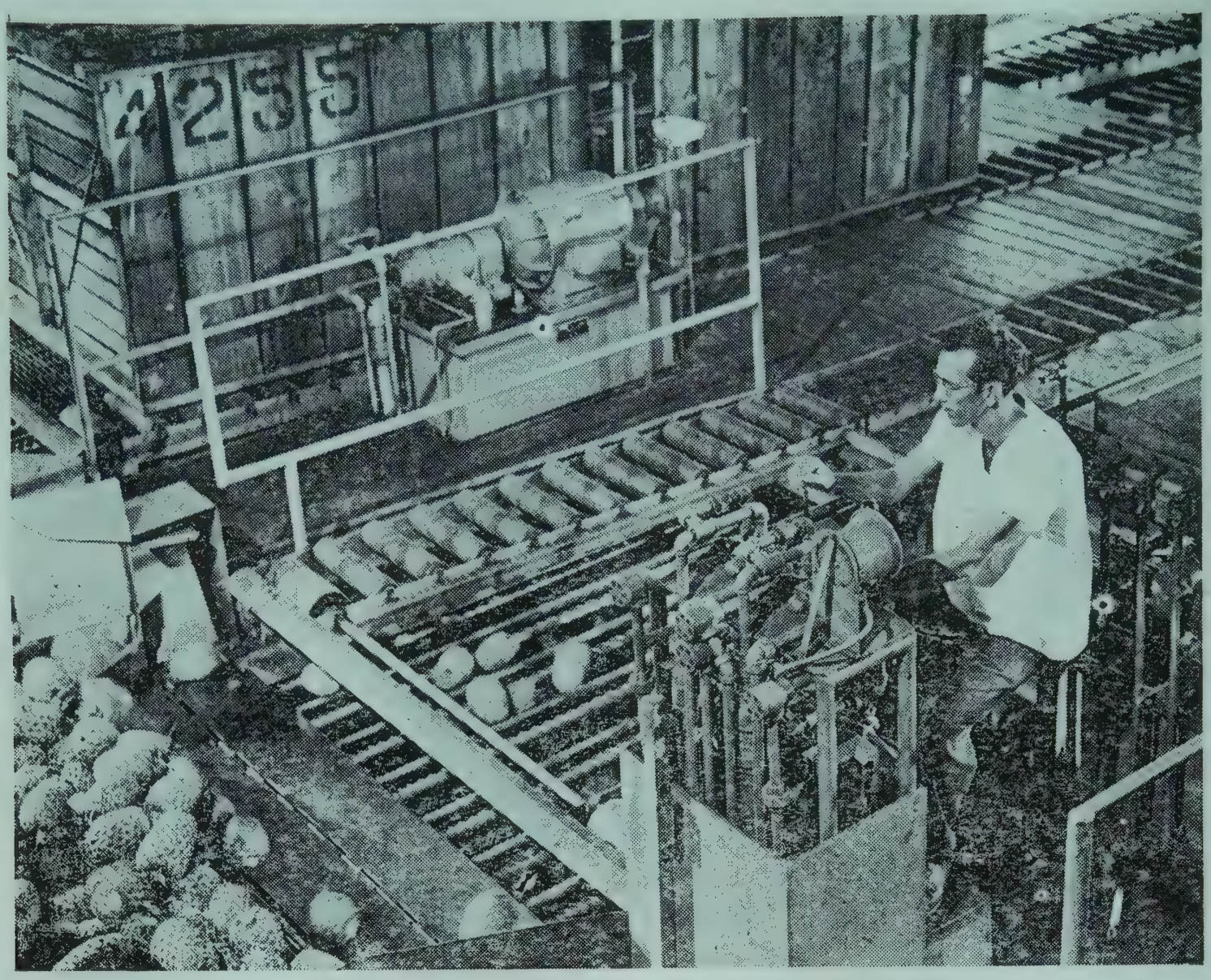
*** FRUIT RECEPTION.**

Straddle trucks remove the bin from the incoming lorry and place it in proper sequence in the fruit storage yard.



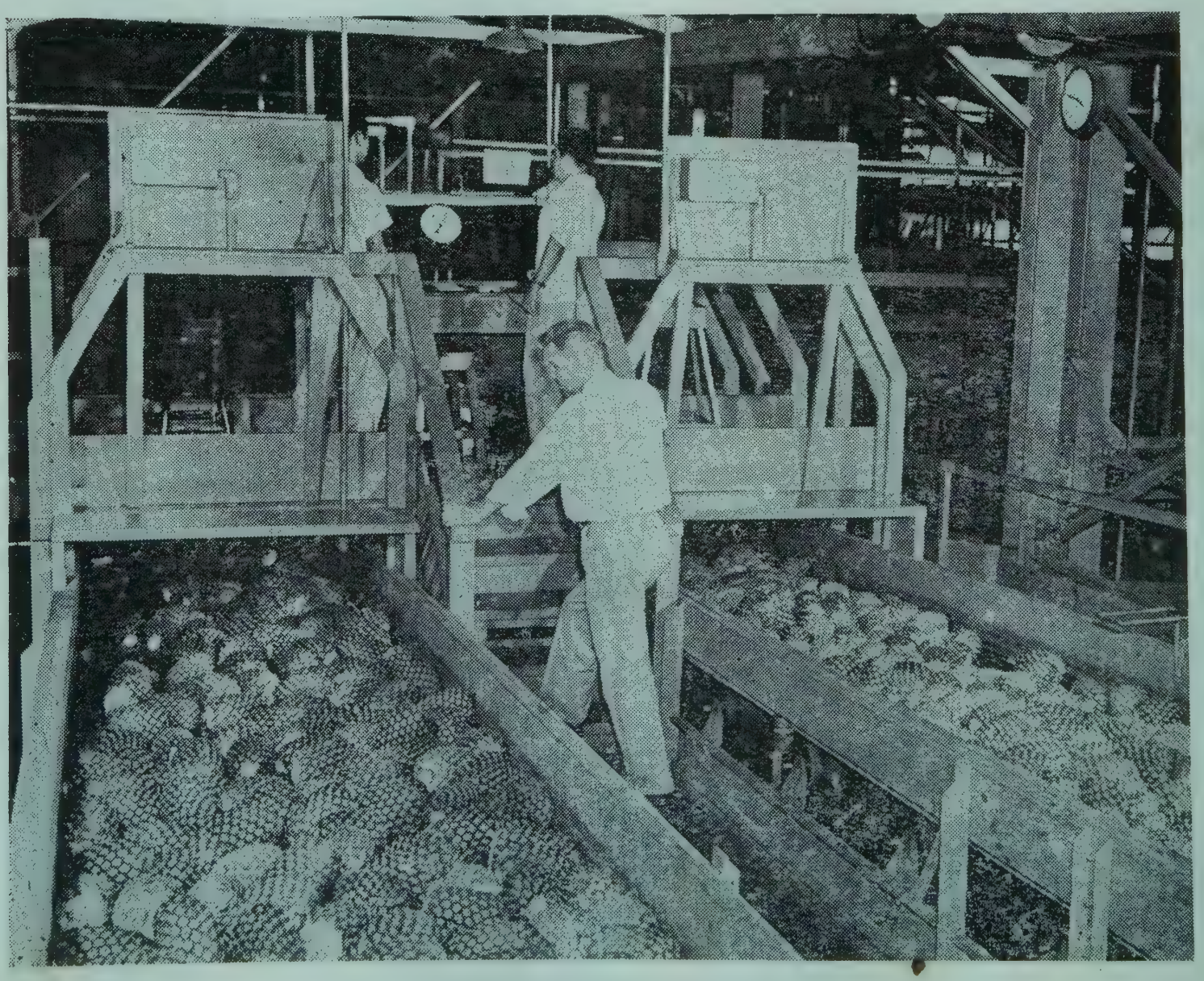
*** FRUIT RECEPTION.**

The fruit is processed the same day within 24 hours of cutting. A bin of fruit is placed on the head of a hydraulic-ram by means of a straddle truck.



*** FRUIT GRADING.**

As the bin tilts, fruit flows in on to the grading rollers. The operator controls tilt, and the setting of the rollers.



*** FRUIT-DELIVERY.**

Fruit flows into the canning line in three continuous streams. Here the large and medium-sized fruits are being continuously weighed. Subsequently they pass under jets of water.

171. The change from lug-box delivery to bin discharge has resulted in a staff reduction from 125 men, who worked very hard, to 20 men who merely operate levers and keep records. The fruit also receives the gentlest possible treatment.

172. The superintendent of this fruit reception department is primarily responsible for the continuous and steady supply of fruit into the cannery and for the efficiency of grading for size. The source of every consignment of fruit is recorded, so that the amount, the size, and the quality of the fruit coming from every field can be promptly reported to the plantation manager, the factory manager and the head of the research department. Appropriate action can therefore be taken immediately, or at a later date, if the crop is unsatisfactory in any respect.

THE MAIN CONVEYOR.

173. The main conveyor belt or belts which receive and carry the fruit on to the various production lines are of heavy five-ply rubber, generally 3 to 4 ft. in width and 50 to 100 ft. long, depending on the lay-out of the factory. The uniformity of its load in some canneries is checked by a continuously-recording Fairbanks weighbridge over which the moving belt passes. This provides a continuous record of the working efficiency of the fruit reception operatives.

FRUIT WASHING.

174. The fruits are generally, but not always, washed before being graded for size. This is partly to remove dust and vegetable fragments and partly to assit the movement of the fruits along the canning line. The fruit is also sometimes washed by multiple sprays while it is passing along the main conveyor belt, but generally, special rack elevators, entirely of stainless steel construction, are employed. These consist of 3 ins. rollers, set at regular intervals between two endless link chains, which draw the fruits up and over an inclined stainless steel plate or up a rack of stainless steel piping set at a slope of 30° while they pass under a rain of spray at 50 lbs. pressure. The fruits are thus rolled, turned, and thoroughly washed while being elevated to a higher level.

175. The wet fruits may pass straight along on to the rollers of the sizing machine, or a more even feed can be secured by means of a progressively curving stainless

steel 'wipe-off', which ensures that the fruits drop off the main conveyor belt in an even spread so that the fruit sizer is able to operate to full capacity.

SIZE-GRADING.

176. The fruit-grading machine in its simplest form consists of a pair of spiral-bound or spiral-cut stainless steel rollers, set in parallel, and rotating in opposite directions. Small fruits fall down through the gap between the two rollers, while the larger fruits are carried along by the rotating spirals on to a second set of grading rollers set slightly further apart so that they are re-sized into medium fruits, which pass down between the rollers, and large fruits which travel on over the spirals, as before.

177. Where larger quantities of fruit are handled, the sizing machine consists of three pairs of these spiral rollers, arranged in parallel. Every alternate roller has fixed bearings, the remaining three have movable bearings which are adjustable by means of a screw which moves all three rollers simultaneously so that the gap between each pair of rollers is the same.

178. It has been found best to use large (8 ins.) diameter rollers with close-set spirals in order to avoid pinching the fruit and irregular sizing, which would occur if one fruit rode the ridges while the next fitted into the recesses of the spiral bindings.

179. The three recognised grades of size for fruit are based on the diameters of the standard cans used to pack cut-slices.

FRUIT GRADES.

Fruit Size	Diameter	Origin.
No. 1 ..	above 5 ins. ..	Mainly plant crop.
No. 2 ..	5 ins. to 3⅞ ins.	Mainly first ratoon.
No. 3 ..	3⅞ ins. to 2¾ ins.	Mainly second ratoon.

180. The number of fruit-cutting machines of each size required to deal with each of the three sizes of fruit is determined by the average amount of each grade in the crop. To allow for variations in the size of fruit from different fields, and in different seasons, a tolerance of 1/16th ins. is allowed in grading, and the grading machine operator is permitted to vary the setting of the rollers this amount, either way, so that either more or less fruit passes through. This ensures that no surfeits or shortages of any grade of fruit can develop due to fluctuations in fruit size.

181. Each of these three grades of fruit has also to be fed to its particular group of fruit cutting machines in such a way that no one machine in the group is over or under supplied. This is effected by means of a system of secondary belt conveyors, known as a 'merry-go-round', the fruit reservoir of the cannery.

182. It consists of two broad, endless, rubber belts arranged side-by-side and operating on very large pulleys. The two belts run in opposite directions so that, by an arrangement of 'wipe-offs' at each end, the fruit can be transferred from one belt to the other, and so can continue to travel to and fro, until required by one of the fruit-cutting machines. The tops of the two belts constitute the 'merry-go-round' for the medium-size fruits, while the inner-sides of the returning lower halves keep the large fruits circulating in a similar fashion.

183. When the supply of fruit in the reception bin of any particular cutting machine is getting low, a lever arm automatically brings into action a stainless steel 'wipe-off' which diverts all on-coming fruit from the 'merry-go-round' down a chute into that bin. Then the weight of fruit causes the lever arm to operate once more and remove the wipe-off so that the fruit once again passes on.

184. One man inspects the fruit in each reception bin and removes any which are over-large, mis-shapen, rotten or overripe, or have crowns still adhering: another man, standing near him, watches the chain feed which carries the fruits one at a time from the bin into the fruit-cutting machine. He helps the fruits on their way and make sure that each of them is correctly orientated against a lug of the stainless steel chain feed, so that no stoppages occur through a fruit jamming.

Peeling and Coring.

185. The fruit-cutting machine used throughout the Islands is based on the original invention of Henry Ginaca of the Dole Pineapple Company, and is the foundation of the Hawaiian pineapple industry. It has been considerably improved and developed but, even now, higher speeds and greater efficiency are still being sought.

186. The latest rotating turret-head machines, of which the largest cannery has twenty-five, are able to deal with up to 125 fruits per minute and cost about $13,000

each. Machines of earlier design, which deal with 40 to 65 fruits per minute depending on the size of the fruit, are also in use in some of the canneries.

187. In the latest machines each fruit as it enters base-forward is gripped and centred by mechanical fingers and then forced against a rotating, cylindrical knife which cuts the skin or 'shell' away from the cylinder of fruit. A fixed, flat knife then halves this shell which drops away from the tubular cutter, while the cylinder of fruit is forced on through the cutter into a recess in the rotating turret-head where it is successively topped and tailed and the hard core removed. Finally the cylinder drops out of the turret-head down a chute and passes in one continuous stream of fruit through a dividing wall of glass and gauze into the next department where the stream bifurcates to feed two packing lines.

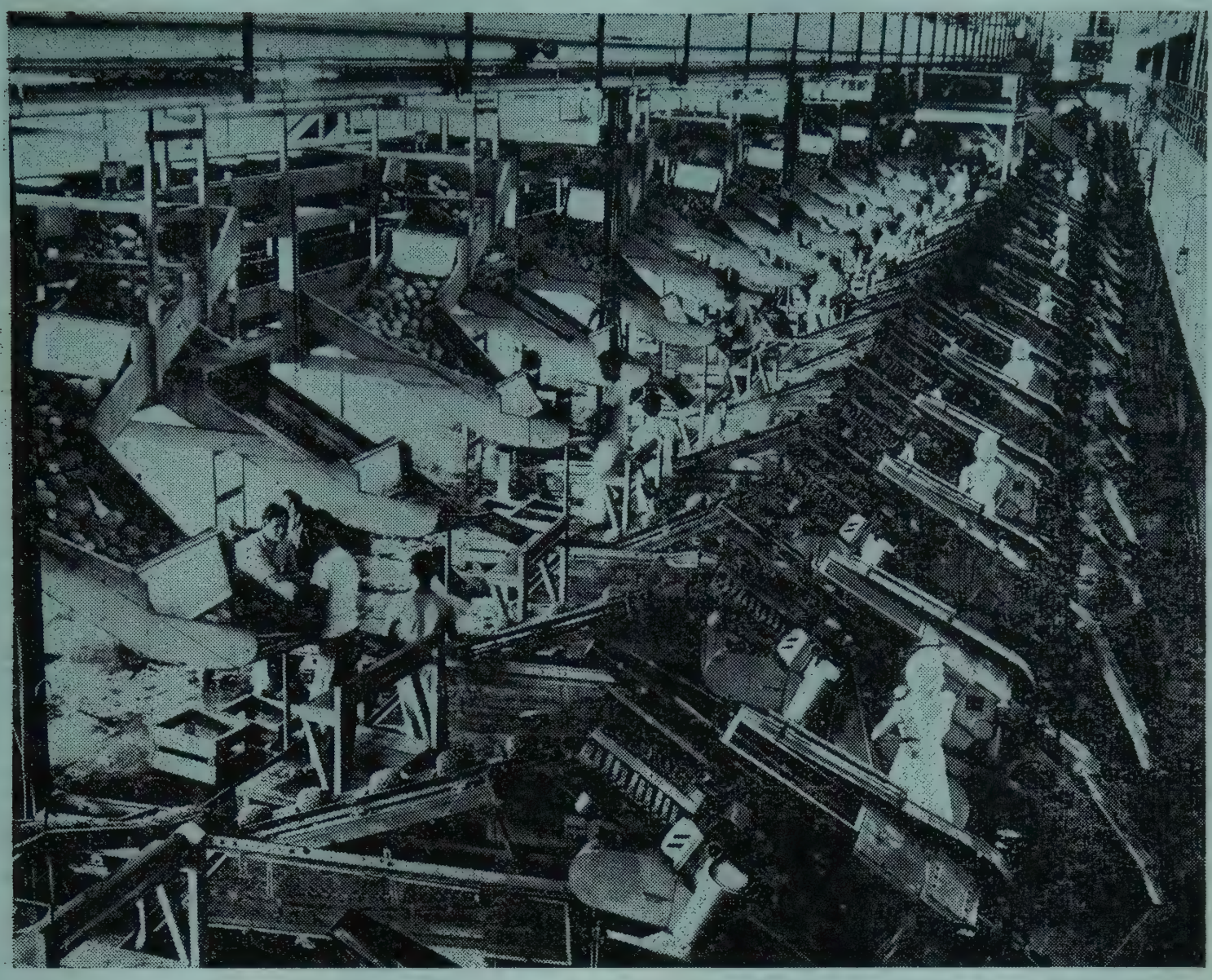
188. Each of these machines is built to cut only one size of fruit. Cylinders of 3¾, 3⅛ and 2¾ inches, result from No. 1, No. 2, and No. 3 size fruit. The cores, while large, are generally well centered in the fruit, and the respective core sizes are 1¼, 1 1/16th and ⅞ inches.

189. The Ginaca machine is unsuitable for a factory with a very small output as the minimum of three machines, one to deal with each size of fruit, obviously could not all be kept in continuous operation. One of the smaller canneries* in Hawaii has 10 machines, 5 of No. 1 size, 4 No. 2, and 1 No. 3., and this appears to be the minimum for efficient and continuous operation.

190. The latest high-speed Ginaca machines need to be kept in perfect mechanical condition. A high degree of mechanical skill and operating experience is required to maintain and operate these complicated machines so that costly mechanical breakdowns or stoppages, due to jammed fruit, do not occur. Where the mechanics and operatives have not sufficient skill and experience to operate high-speed machines without frequent stoppages, it is said to be more efficient to operate with the slower machines.

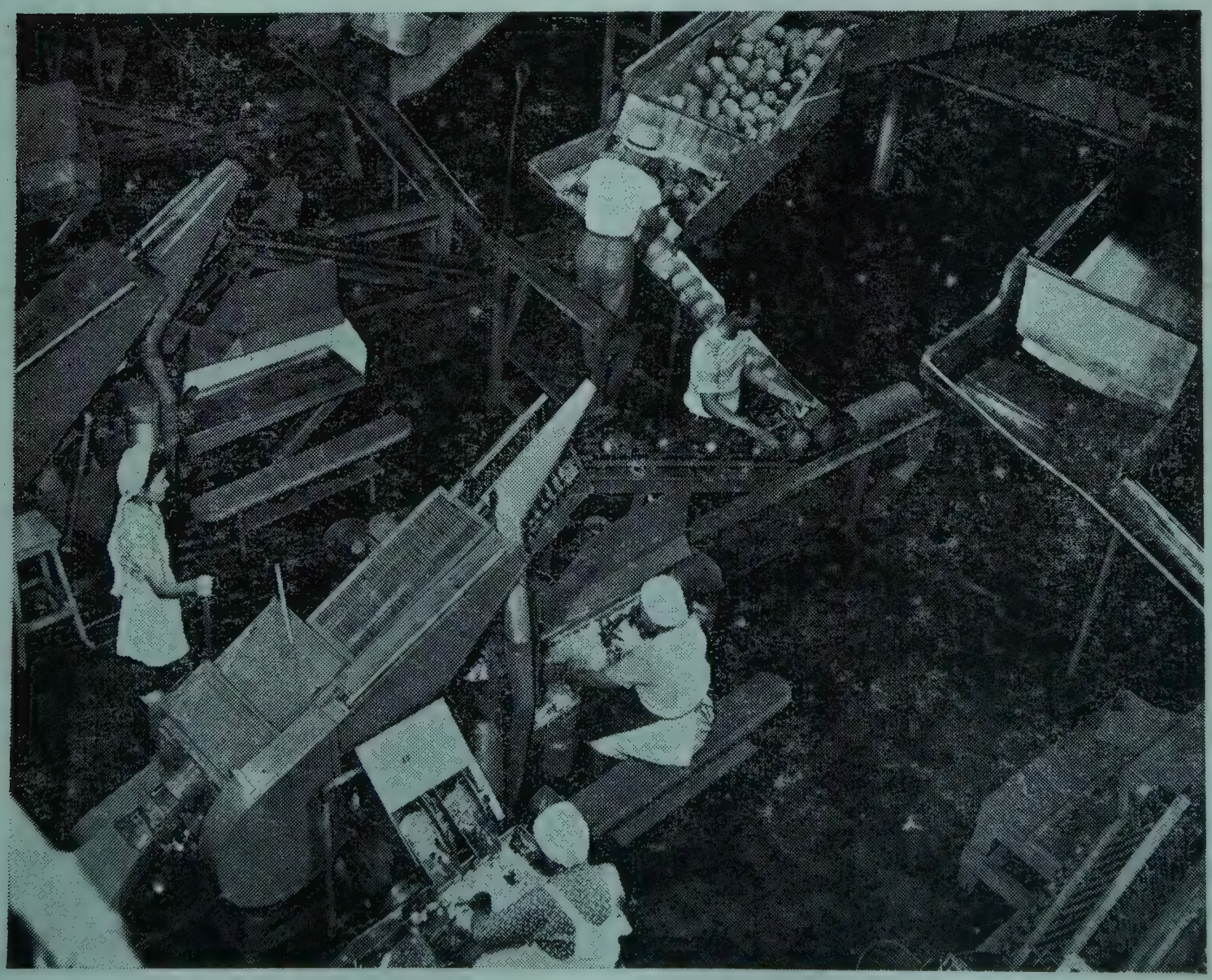
191. The fruits must be cylindrical. The Ginaca machine is said to be of no use for fruit which is oval or near-round because of the low recovery rate of cut fruit. In Hawaii, the yield of cut fruit slices is apparently about 16 per cent. of the weight of the whole fruit, but with small oval or round fruit with deep eyes only about 10 per cent.

* Output about 500,000 Malayan-size cases per annum.



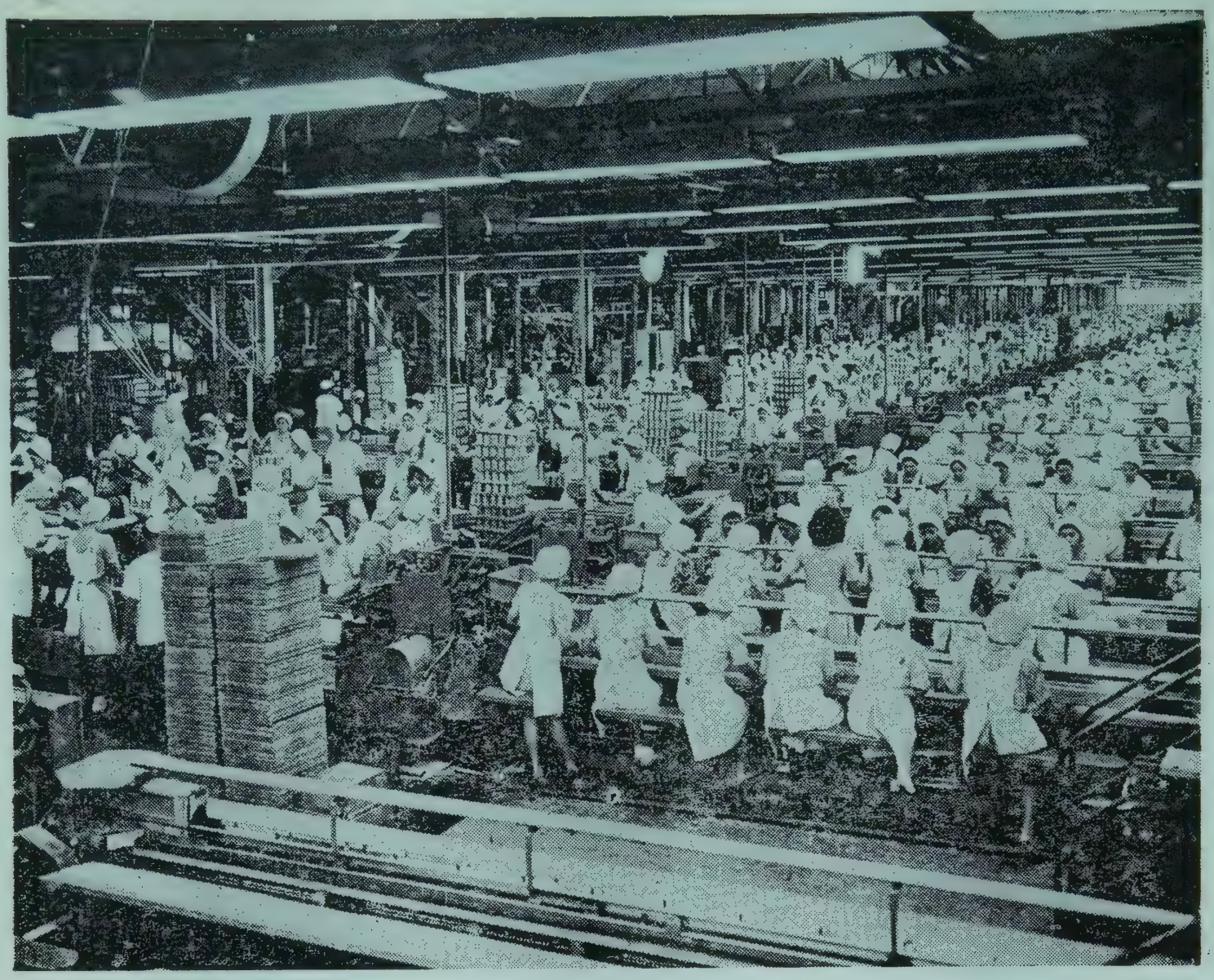
*** FRUIT PREPARATION.**

A battery of Ginaca machines with the fruit merry-go-round in the background. The fruits enter on the left and leave as fruit cylinders by the stainless steel tubes on the right.



*** THE GINACA MACHINE.**

This machine tops and tails the fruit, removes the shells and cores, and eradicates the white pulp from the green shells. The fruit flows from right to left in a continuous stream.



* PARALLEL CANNING LINES.

The fruit cylinders flow in a continuous stream from right to left. The trimmers remove blemishes, the fruit is mechanically sliced and finally is graded.

* TRIMMING.

Close-up of girls removing bits of peel missed by the Ginaca machine. Fruits enter by the half-round channel, are trimmed and placed on the stainless steel lug belt.

could probably be recovered. Such a low yield would increase, beyond saleable limits, the amount of crush and juice produced from the eradication of the white pulp from the shells.

ERADICATION.

192. The fruit shells, which fall away from the peeler and corer, are seized by a spiked drum which flattens the skins and forces them over a set of vertical and horizontal knives which slit and slice, and so 'eradicate' the white fleshy tissue. The ends of the fruit are also eradicated. (The eradicator here is an integral part of the Ginaca machine, but it can also be a separate machine for operation in conjunction with other types of fruit cutter).

193. The eradicated pulp passess out at two points on opposite sides of the Ginaca over finely-punctured stainless steel plates so that any free juice can drain away along stainless steel pipes to the juice plant. Two girls sort the pulp and divert speckled pulp down one stainless steel chute and white pulp down another on to two rubber conveyor belts leading to the juice and crush plants respectively.

194. The waste products of this machine are thus:—

(*a*) juice;
(*b*) speckled pulp, and
(*c*) cores which are both pressed to obtain canning syrup;
(*d*) white pulp which is converted to pineapple crush;
(*e*) green outers which are used as cattle food or are sent to the bran plant.

The solid products are carried away on rubber belts, running between stainless shielded walls and shielded by boarded covers to prevent contamination from above.

195. The minimum staff required to operate the Ginaca, irrespective of its output, is 2 men to inspect and feed fruit into the machine, 1 girl to operate it, and 2 girls to sort the eradicated pulp. The delivery of fruit to and the removal of products from this machine is, as previously described, all done mechanically, so there is no movement of personnel within this department.

II. Packing.

TRIMMING.

196. The cut fruit cylinders (see para. 187) slide down an inclined, stainless-steel, trough and come to rest in a half-round shelf above a stainless steel trimming table

where twelve or more rubber-gloved, white-aproned girls remove blemishes with special knives. They cut out deep eyes, bruise marks, portions showing fruit rot, ragged ends, and any pieces of green skin which have missed the rotary cutters owing to the poor shape of a fruit. The fragments, so removed, are dropped through a hole in the bench and are conveyed away to the juice extraction plant, while the trimmed cylinders are placed on a stainless steel link belt, fitted with lugs, which carry the fruit on towards the slicing machine.

SLICING.

197. The mechanical slicer has a multiple knife with either 11 or 21 vertical stainless steel blades, set in parallel at equal intervals. The knife rotates on a horizontal axis, so that the blades pass through 21 slots in a horizontal stainless steel tube through which the cylinders are forced in continuous pulsating procession with a regular pause to allow the knife to slice through the line of fruit.

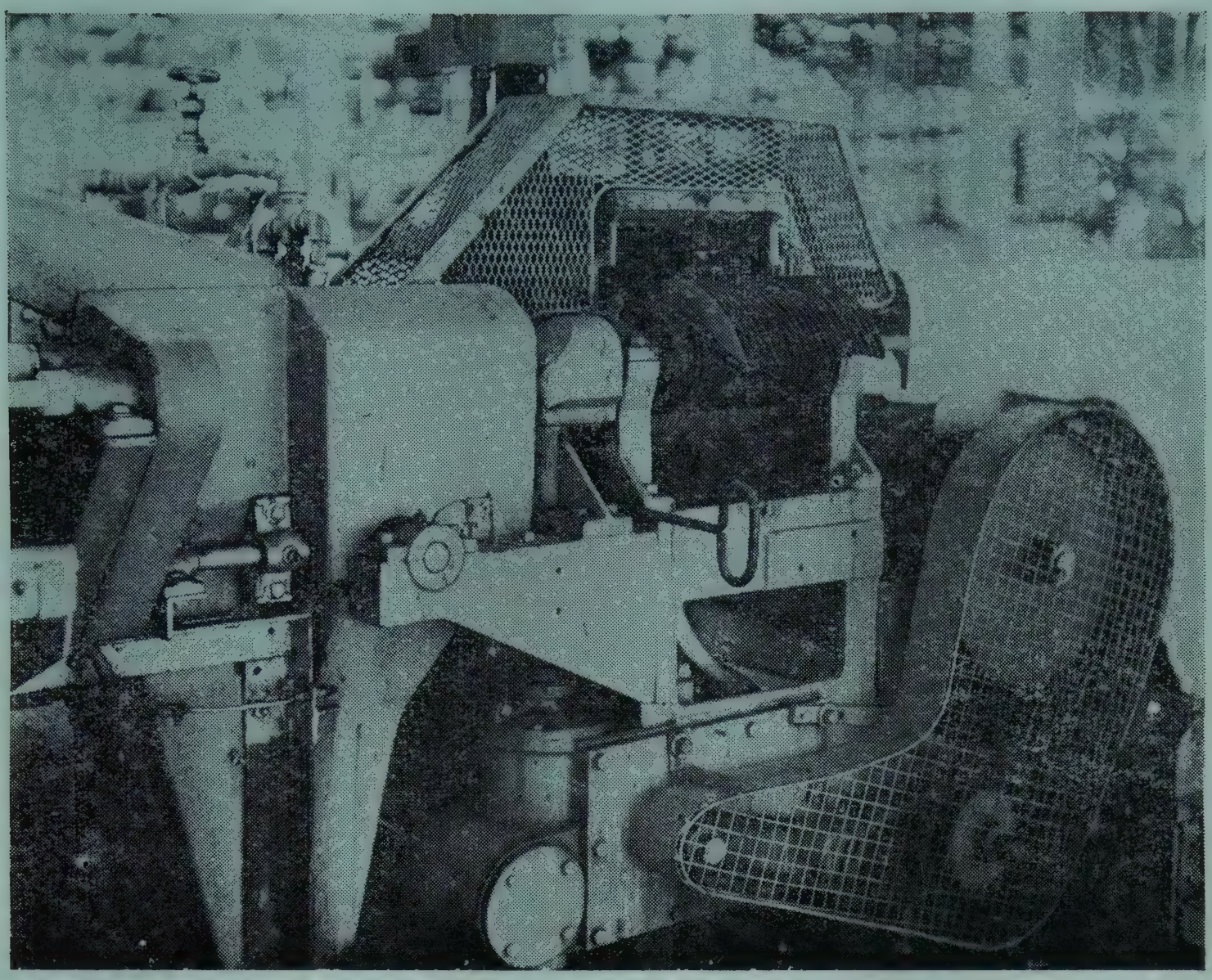
198. An integral part of this machine is a spray washer which removes, before the fruit is sliced, any adhering fragments left by the trimmers.

199. The slicing machine is simple and efficient, and yields (except for the two ends) exactly uniform clean-cut slices. Slices are cut in two thicknesses, 1 in. and ½ in. The former are for subsequent conversion into chunks, the latter are packed as slices, eight to an A2½ size can.

SORTING AND GRADING.

200. The sliced fruit emerges continuously from the slicer and is carried on an endless stainless steel band conveyor down the centre of a stainless steel packing table. On one side of the belt is the working bench where the fruit rings are graded, and, on the other, there is an inclined rack to carry the trays of cans into which the graded fruit is put.

201. Grading is based on colour, texture and physical uniformity. The girls at the head of the line pick up a group of rings, spin them, select the perfect yellow slices for the 'fancy' pack, and then replace the rejects on the belt. Girls in the middle of the team remove the remaining whole slices from these rejects for the 'choice' pack, and allow the broken, thin or irregulary-cut slices to pass on to the third group of girls who pick out any sizable segments



* WASHING AND SLICING.

The cylinders flow in a continuous stream into the washer and slicer. Blades of rotating knives enter slots in a fixed hollow tube. Inside, fruit cylinders are stopped momentarily for slicing.

* SLICE GRADING.

Girls at the head of the line pick up a group of rings from the stainless steel conveyor belt, spin them, select the perfect yellow slices and replace the remainder on the belt. (Note visual standards).

or broken rings for the 'standard' pack, leaving the thin ends and small broken pieces to be conveyed away to the pineapple crush plant.

SPECIAL PACKS.

202. On one packing line, thick-cut, 'fancy' grade, yellow slices are converted into segmented chunks for the new 'deep-freeze' carton pack, while similar chunks obtained from the residual 'standard' slices are canned as "pineapple chunks". Broken rings, or sizable segments may be packed as "broken slices", or they may be reduced to exact "halves", or converted into "tidbits".

203. The chunk cutter and the tidbit cutter work on the same principle. A thick or thin slice is forced by a ram through a segmented circular die. When dealing with broken segments, hand-feeding and hand-operation is demanded, but when whole rings are converted into chunks they can be pushed mechanically in groups of 10 or 12 in front of the head of a reciprocating ram and forced through the die mechanically.

204. The analysis of the Hawaiian pack for the 1946 season, expressed in terms of standard fiberite cases is as follows:—

Grade	Type	Standard Cases	Percentage of Total Pack.
Fancy	Sliced	3,856,000	25
Choice	Sliced	755,000	
Standard	Broken Slices	435,000	12
„	Chunks	1,068,000	
„	Tidbits	761,000	
Crush	Sweetened	2,819,000	18
„	Unsweetened	543,000	
Juice	—	8,207,000	45
	Total	18,444,000 Cases	

205. It will be seen that 70 per cent of the pack of cut fruit is of 'fancy' grade, which is indicative of the uniformly yellow colour of the raw fruit, while the amount of by-product crush and juice, for which a market has to be found by high-pressure advertising and salesmanship, amounts to almost 12,000,000 fiberite cases, (i.e. 6,000,000 standard Malayan cases).

CAN SUPPLIES.

206. Cans are manufactured for the pineapple industry by an independent company with a large research organisation and long experience of can-making for many different industries. It has not only made and sold cans to the pineapple canners; it has also entered into the problems of the industry and contributed to their solution.

207. The canners consider that can-making is a specialist industry outside their province, and prefer to buy cans rather than organise a subsidiary company to manufacture them for the industry on a co-operative basis, so long as price and service continue to be satisfactory. The standard of efficiency is certainly high as only about 4 cans in every 10,000 delivered to retailers are defective which is well inside the statutory limit of five per thousand.

208. The cans are produced, to the extent of several hundreds of millions annually, in five factories, distributed over the islands of Oahu, Maui and Kauai. They pour into the canneries incessantly in swift procession along a number of parallel conveyor lines; they are either mechanically stacked or else conveyed direct to the production lines for immediate use. Cans entering the processing lines are mechanically washed and steamed as they move along the conveyors.

209. They are produced in five standard sizes, based on the specifications of the National Canners Association of America, and in 1946, the output was as follows:—

CAN PRODUCTION IN 1946.

Trade Description	Size Dia. x Ht.	Cans (millions)	Cans per Case	Number of Cases	Percentage of Total Pack.
A2	307 x 409	243	24	10,122,000	55
No. 3 Cylinder	404 x 700	16	6	2,720,000	15
A2½	401 x 411	54	24	2,231,000	12
A10	603 x 700	11	6	1,904,000	10
A1	301 x 400	70	48	1,407,000	8
	Totals	394		18,384,000	

RELATION OF FRUIT AND CAN SIZES.

Ginaca Size	Fruit Diameter	Slice Diameter ins.	Can Diameter ins.	Can Size
No. 1	above 5 ins.	3¼	4 1/16	A2½
No. 2	5 ins. to 3⅞ ins.	3⅛	3 7/16	A2
No. 3	Below 3⅞ ins.	2¾	3 1/16	A1

210. As will be seen, the A2, a 20 oz. can giving an 18 oz. fill, is the most favoured size, and the 'fancy' grade, mainly derived from medium-sized fruits, is mostly packed in this size of can. The less sweet, but larger, plant-crop fruits, a great deal of which goes to make up the 'choice' pack, is principally packed in the A2½ size can. The A1 cans are for the smallest diameter fruits which mostly yield 'fancy' pack.

211. As regards special packs, A2 is the principal can size for 'crush', though A1 provides a convenient size for domestic use. The A2 can is also the leading can size for 'chunks' and juice, but 'tidbits' which are required mostly by the catering trade for fruit mixtures, go out mostly in the large A10 or gallon can. The No. 3 (46 oz.) cylinder is a middle-size pack for juice.

CAN FILLING.

212. In most canneries where food products are packed, empty cans are normally delivered to the packing tables and removed continuously by means of conveyors, but in Hawaii, there is a slight break in the continuity of production in all factories at this point. There are several probable reasons. Firstly, there is the risk, with continuous-line production, that the grades of fruit could get mixed; secondly the conveyor system would be very complicated; and thirdly, the out-turn of sizes and grades varies seasonally for different fields, so that it would not be possible to integrate the filling and grading lines with the processing lines without having valuable machinery, lying idle in reserve, to allow for these variations.

213. Confusion of grades is avoided by the use of painted trays on which the cans are delivered to the grading tables. These may be coloured say red for 'fancy' yellow for 'choice', and green for the 'standard' pack. These trays, loaded with 18 cans each, are delivered to the tables in stacks of twelve or thirteen, according to can size,

and are laid out on the inclined rack to be filled with the appropriate grade of fruit by girls seated on the opposite side of the belt delivering the sliced fruit.

214. The trays used are of simple three-ply wood construction, 18 x 12 ins. in size, with a rim 1 in. high, enclosing three sides only. The stacks of empty cans and of filled cans are delivered and removed on platforms or palettes by means of simple two-wheeled porter's trucks.

PACKING EFFICIENCY.

215. To ensure uniformity of trimming and grading, irrespective of weather conditions outside, (*i.e.* overcast or sunny) standard conditions of lighting are provided in the packing department. A line of tubular fluorescent lamps, placed end to end, above each trimming, grading, and packing line, provides brilliant daylight conditions.

216. The work is very closely supervised, for carelessly deep cutting by the trimmers reduces the yield of perfect slices, and any unnoticed blemishes affect the quality of the pack. Grading standards are maintained by means of showcase of coloured wax models so that they do not change imperceptibly owing to seasonal variations in the nature of the fruit.

217. There is a large staff of supervisors in this department. A female inspector at each trimming table watches the work of twelve or more girls, and another at each grading table checks the cans of fruit after they have been filled. Thus a cannery equipped with twenty-five Ginacas and with fifty of these canning lines has a total packing staff of about 1,250 girls supervised by 100 inspectors, 2 supervisors, and a manageress.

III. Processing.

218. After this slight break in the continuity of production, continuous flow is again resumed during the next stage, *i.e.* processing. There are a number of processing lines, but except for one cannery each of these lines deals with only one size of can, since the guides and can recesses of the machinery are of fixed size. The stacks of filled cans are brought to the appropriate reception point, and the trays are placed one by one, in succession, on a conveyor belt provided with a wipe-off device which sweeps the contents of each tray on to the feeding discs of the first

machine in the processing line, while the empty trays pass on under the wipe-off arm and are collected and stacked ready for refilling.

219. In Hawaii, continuous mechanical processing includes either vacuumising or exhausting, syruping, can sealing, cooking and cooling. The object is to obtain a commercially sterile, airtight can of fruit, with a vacuum of 11 ins. or more, in the shortest possible time so that the colour, flavour and aroma of the product are not impaired during processing or by 'stack-burning' afterwards, and so that maximum output can be obtained from the available equipment at the lowest possible cost. Three different methods are being used.

THE VACUUM PROCESS.

220. The latest and most up-to-date method is to pre-vacuumise the open cans of fruit mechanically for about 30 seconds, then add hot syrup with a rotary syruper, close the cans with a vacuum seamer and finally cook them in a rotary pressure cooker through which they pass in continuous procession along a spiral path.

221. The initial vacuum sucks the air from out of the cut fruit and the hot syrup added immediately afterwards takes the place of the air that formerly filled the inter-cellular tissues. Then vacuum is again applied while the can is closed so that each can has in it a vacuum corresponding to that applied in the sealing chamber of the can closer.

222. Cooking under pressure forces the last traces of air from the cells, thereby deepening the colour, and the higher temperature of the pressure cook is so much more lethal to yeasts and bacteria than is the ordinary atmospheric cook, that the cooking time can safely be reduced from say 12 minutes to about 8 minutes. The plant is of course more complicated, elaborate and expensive than that used in the exhaust process with the open cooker but as it is capable of dealing with 180 cans per minute and requires only about half the overall processing time, it is being applied where outputs are large and factory space is restricted.

THE EXHAUST PROCESS.

223. In this, the syrup is added to the fruit, and the open can is then pre-heated in a continuous steam exhauster or hot box for 5 to 6 minutes, or more, according to can size.

It is then closed and, finally, it is sterilised in a continuous open, agitating cooker for 12 minutes, or more for the larger cans. The overall processing time is thus over twice as long as the vacuum process, *i.e.* 17 minutes or more.

224. The exhauster has a threefold function. It preheats the contents of the can to a temperature near to boiling, so reducing the time the can has to be in the cooker; secondly it expands the contents of the can so that after the lid is put on, a vacuum is created; and thirdly it forces, the air from the intercellular spaces thereby deepening the colour of the product.

225. Until recently this sequence of processing was standard practice in most of the canneries. Some canneries are now adopting the vacuum process, and others, still using the exhaust process, are rearranging their processing lines so that the can of cut fruit is first exhausted without any added syrup. It is then automatically tipped to drain away condensed water, filled with hot syrup, and finally closed and cooked.

226. The reason for this change was threefold *. The agitation of the cans in the open disc-exhausters was liable to cause spillage of the contained syrup, resulting in underfilled cans, the syrup strengths were liable to be irregular, owing to the condensation of steam, and there was also a cleaning problem, because any spilled syrup finds its way into the moving parts of the exhauster.

THE EXHAUSTER.

227. Disc-exhausters are standard in all canneries, not using the vacuum process, except one. In this single instance a cannery-made chain exhauster is used because, owing to the close proximity of the sea, disc gears were found to corrode away too rapidly.

228. Otherwise, in Hawaii and in America too, the disc-exhauster is preferred to the chain exhauster. It is said to give very little mechanical trouble and, with regular lubrication and cleaning, can be operated for 5 years without re-bushing. It was stated that the links of the chain

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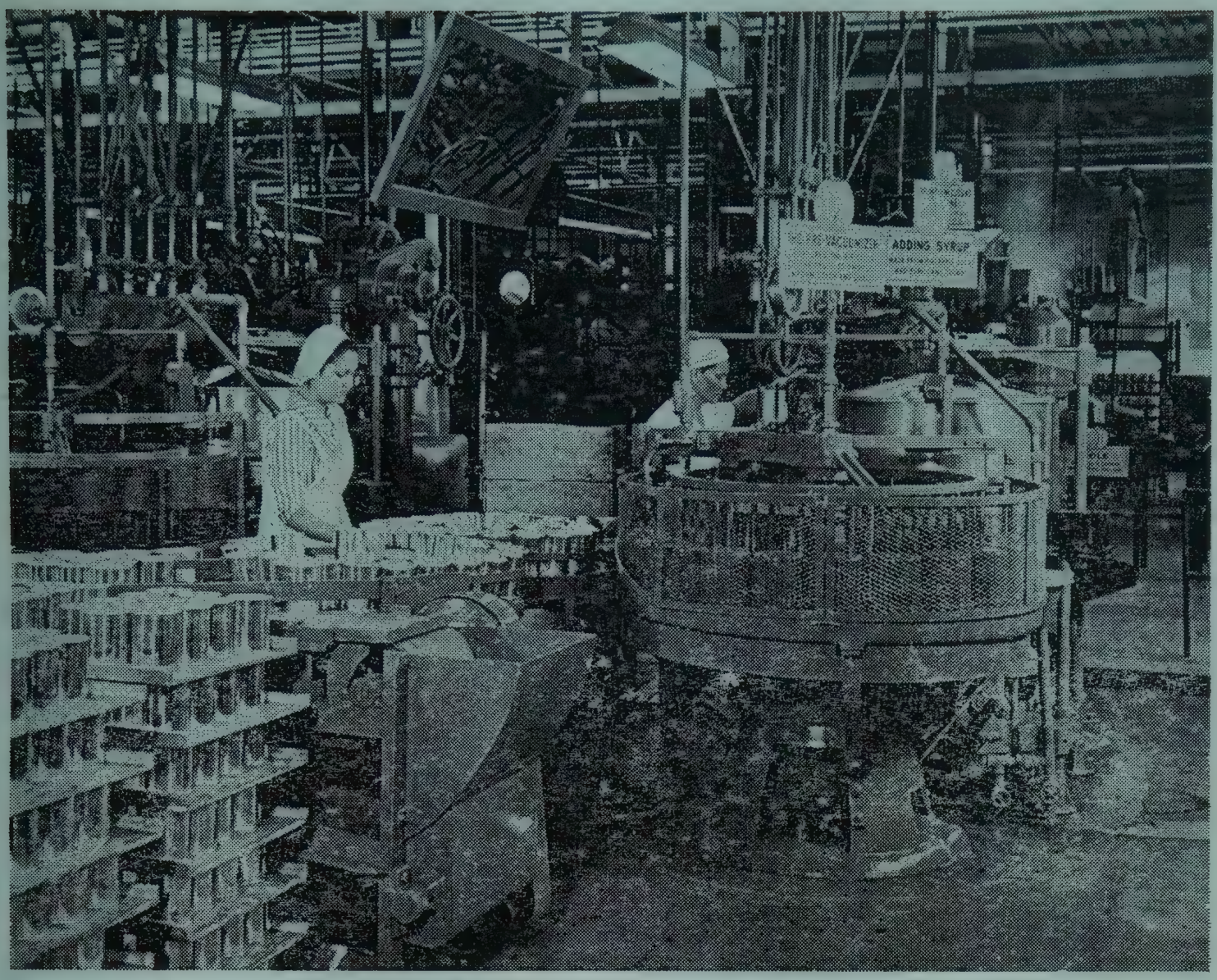
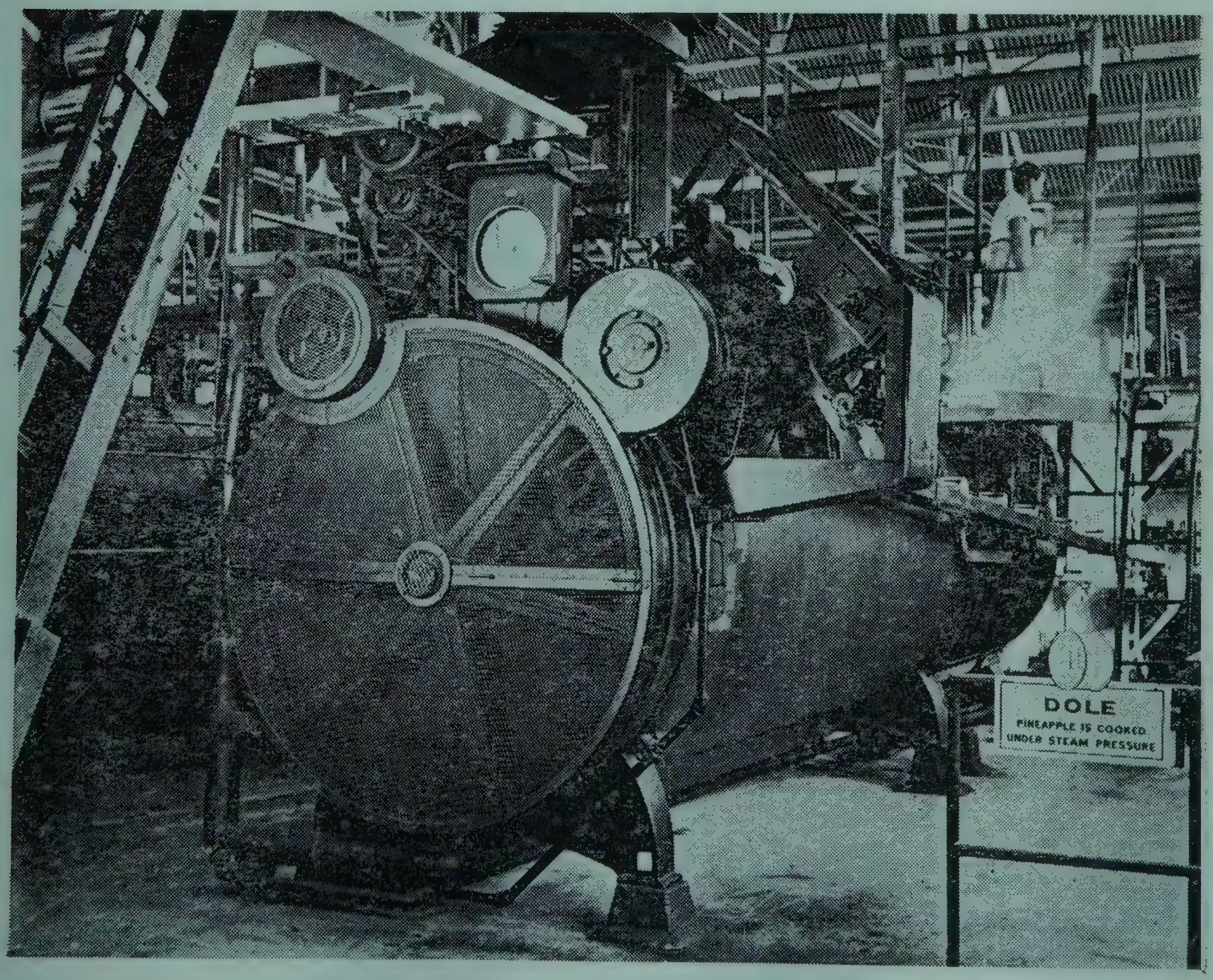
* In British practice, these troubles are overcome by 'clinching' the cans before exhausting. The can lid is put on, but only the 'first operation', the curl, is applied, so that air can still escape from the can but no spillage or dilution of syrup can possibly occur.



*** PROCESSING.**

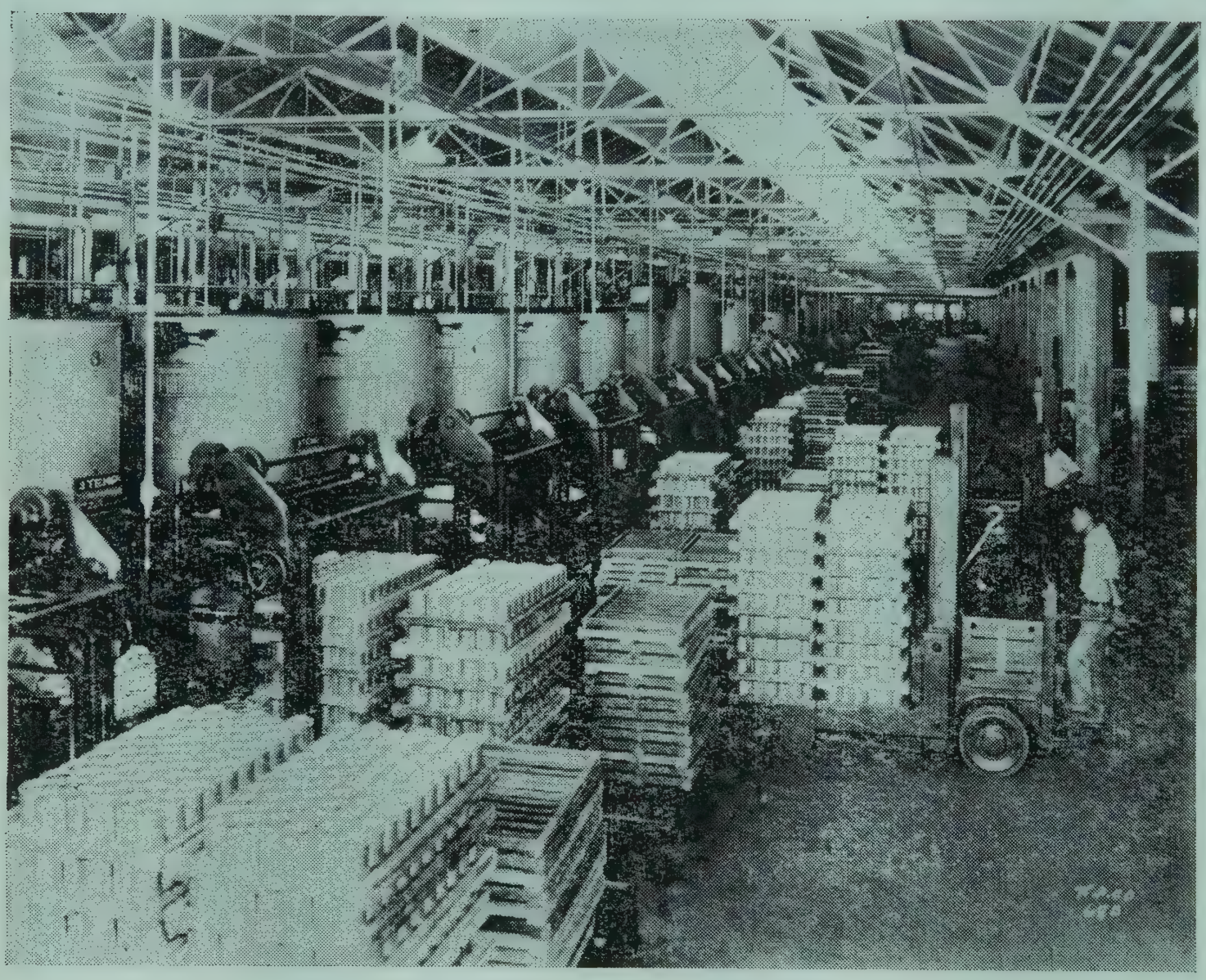
Filled cans of fruit are checked by an Inspector as they pass into the pre-vacuumiser (or the exhauster) and thence to the syruping and closing machine.



*** PROCESSING.**

The closed cans of fruit pass on through continuous rotary cookers and, following a spiral path, are sterilised by steam.

PLATE 21.



* COOLING AND STACKING.

The cans are next rapidly cooled by passing up through continuous rotary coolers. As they emerge they are mechanically grouped and stacked on trays and taken to the cooling room on 'finger-lift' electric trucks.

exhauster wear, the chain stretches, and may even break, and that any such breakdown of a hot exhauster results in a major stoppage of production.

SYRUPING.

229. The cut fruit may be packed in water or in unsweetened juice for commercial use; or in concentrated juice, sugar and juice or sugar and water, of a strength appropriate to the grade, as follows:

SUGAR STRENGTH.

Grade	Before Canning	After Canning
Fancy Slices ..	45—55° Brix	24° Brix
Choice Slices ..	30—35° „	20° „
Standard Broken ..	20—25° „	17° „

230. Recovered juices used for canning are gauged, blended and strengthened with sugar to the required degree in stainless steel mixers. They are delivered from the syrup room to the processing lines along stainless steel pipelines, painted in five different colours, according to the strength of syrup in each. In one factory the syrup used is plain sugar juice recovered from the bitter juice derived from the skins (see "Ionisaton Plant").

COOKING.

231. The use of stationary tank cookers, which require 30 to 35 minutes, according to the grade of fruit, to sterilise an A2 can, was discontinued 38 years ago. The cans are now sent continuously through agitating cookers, operating either at boiling point in the open type of machine, or at temperatures above boiling point in the more complicated pressure cooker.

232. As a result of agitating the cans by slow-rolling, heat penetrates much more rapidly and throughout the contents, so that very rapid sterilization can be effected without overheating the whole, or any part of the contents.

233. With one exception, agitating cookers are of the rotary type in which the cans are carried by guides along a spiral runway from one end of a cylindrical chamber to the other, so that there is a constant turnover of the contents of each can. In one cannery there is a tunnel cooker in which the cans are rolled forward by spacing rods, set at regular intervals between two endless moving chains, through a steam-heated chamber at the rate of 120 cans

per minute. Heat penetration trials, it is stated, have shewn that with this type of machine only a 4 minute cook is necessary.

234. The actual cooking times with the open type of cooker need, of course, to be related to the period of exhaust during which the contents are being pre-heated. These periods range from 4 to 27 minutes depending upon the size of the can, the ripeness of the fruit, and the type of cooker. In one cannery, using exhausters, the practice is as follows:—

	PERIOD OF:—		
Can Size	Exhaust	Cook	Total
	Mins.	Mins.	Mins.
A2	5	12	17
A2½	6	15	21
A10	8	27	35

COOLING.

235. Leaving the cookers at 195° F., the cans pass on continuously to the coolers where they are in contact with cooling water for 4 to 6 minutes. The temperature is sharply reduced, so that any overcooking of the product is avoided. With the Cayenne pine such cooling is regarded as essential since, with prolonged after-heating, there is a colour and flavour change and the resulting product is not so good.

236. If, however, water-cooling is unduly prolonged the cans do not dry properly and they are apt to rust in storage. It is considered that the emerging cans should not be colder than 90° F.

237. A product called "Aerosol" has been used to reduce the surface tension of the water so that it runs off the emerging cans as they roll along the runways. A counter-current of hot air has also been tried.

238. Four types of coolers are used:—

(*a*) Vertical rotary cooler;

(*b*) Horizontal rotary cooler;

(*c*) Water-sprayed moving belt;

(*d*) Water-sprayed inclined plane.

In the first type, the cans enter at the bottom and are discharged at the top, while cold water flows in at the top and emerges at the bottom. As in the rotary cooker, the cans are carried by guides up a spiral runway to the top

The horizontal rotary cooler is similar, but occupies more floor space. It is connected to, and follows immediately after, the horizontal rotary cooker.

239. The belt cooler is a continuation of the tunnel cooker, previously described. The spacing rods of the conveyor continue to drive the rolling hot cans forward under a rain of cold water.

240. The fourth type is simply a long inclined plane, consisting of a canvas runway with a slope of 5°. The cans slowly roll through an initial rain of spray and subsequently they are cooled by the film of water on the surface of the canvas as they move on down the runway towards the wrapping machine.

241. In all these coolers, the agitation of the cans by slow rolling disturbs the contents and constantly brings fresh hot material in contact with the cold can surface, and heat transfer is thus more rapid than if the can remained stationary under a rain of spray. Furthermore, the process is continuous.

IV—Warehousing.

Can Storage.

242. In some of the smaller factories, labelling and casing follow on continously without a break, but generally, it is considered better practice to keep the cans overnight in stacks in a cooling room, so that they may dry, cool further and be tested for vacuum the following day by sounding each can with a light metal rod, so that there is no possibility of any defective cans leaking in subsequent storage or reaching the customer.

243. These stacks may consist of trays of cans placed one above the other, to a height of 6 ft. or more, and standing on wooden palettes. The latter are built up mechanically by means of a fully-automatic tray-filling and stacking machine which collects 24 cans into each tray, lifts it and places it on top of the stack it is building.

244. An alternative method is to build up stacks on the palettes with fibre-board separators by hand. This is done by collecting cans, four at a time, with a special fork from the can runway. These fibre-board separators serve as trays and make possible a smooth 'wipe-off' on a conveyor, whereas the wooden rack trays are expensive in wear and tear and the cans are ejected by tipping each tray on to an inclined steel plate with some risk of denting.

245. The largest cannery has a cooling area sufficient for between six and eight million cans. The stacks of filled cans remain here overnight, on the same platforms or palettes on which they were originally built, ready for quick removal by mechanical aid, without further manhandling. Movement in or out of this cooling room is by the Yale Electric Hauler or the Clark finger-lift truck, according to the size of the cannery. The former is used to haul a train of stacks on bogies, the latter is for elevating and moving individual stacks.

Labelling And Casing.

246. On the following day the cans are again on the move. They are tested and then fed, in trayfuls, to an elevator which raises them to a suitable height before sending them rolling, by gravity, along strip-steel runways towards a labelling machine which applies from 350 to 1,400 labels per minute, according to the type of machine and the size of can. From here they roll onwards to a casing machine which arranges and offers the cans in groups of twelve to a waiting attendant who holds an open fiberite container ready to receive them. The filled cartons are conveyed along a moving balata belt on which they are automatically gummed, sealed and branded.

247. The cartons are again elevated by rack or belt conveyor to a suitable height before being sent, by gravity, along a line of free-running roller conveyors leading to any desired point in the warehouse where they are stacked on palettes ready for moving and lifting onto lorries or into the hold of a ship without breaking or rebuilding the stacks.

MATERIALS AND EQUIPMENT.

Stainless Steel.

248. Perhaps the most striking feature in all of these canneries is the lavish use that is made of stainless steel which has replaced aluminium, galvanised iron, copper, brass, acid-resisting concrete, glass porcelain tiles, enamel and wood as a material of construction for surfaces in repeated contact with whole or cut fruit.

249. Stainless steel, due to technical difficulties in its manufacture, is extremely expensive, but cannery technicians were all firmly of the opinion that, in the long run, it was both the cheapest and the most satisfactory material

to use. It was said that " fruit chutes made of galvanised iron only last six months but you can fit and forget stainless steel." Stainless steel is completely unaffected by fruit juice and cleansing solutions, and is said to last for many years.

250. It is preferred to rubber, for use in contact with cut fruit or juice, because it is more easily washed and rendered sterile. It is much preferred to aluminium which pits and corrodes away, and at the same time impairs the flavour of juices.

251. Knives, scoops, buckets, fruit bins and screens and the moving parts of all machines used to cut, slice, eradicate, shred, or press fruit, and all pipes, valves, floats, storage tanks, syrup mixers, crush cookers and syrupers are naturally made of this alloy. But in addition to this, endless link belts, chain drives, sheet band conveyors, conveyor guides, wipe-off devices, chutes for whole or cut fruit, fruit washing machines and complete trimming and grading benches are also constructed of this material. It is said that stainless steel band conveyors ride badly on the driving pulleys and are liable to crystallize and snap Nevertheless they are used in almost all the canneries for conveying cut slices along the grading benches.

Rubber.

252. Rubber, probably the only other satisfactory alternative, has special uses. The very extensive arrangement of extra heavy and heavy rubber belts which constitute the fresh fruit reception and distribution system represents a very necessary, but heavy, item of recurrent expense. Rubber is also used for gloves and aprons, as a liner for juice tanks and pipelines, and for the wheels of hand trucks or electrically propelled tractors and bogies which pass over the concrete or asphalt floors of the cannery.

Floors.

253. Floors remain a problem. Ordinary cement floors built for hand trucking are said to be of no use for mechanical conveyance, even with rubber wheels, and they are not acid resisting. A mixture of basaltic lava, sand, and cement with reinforcing bars, or asphalt are used in these canneries and this surface gives fair service. A rubber-surfacing composition has been tried with promising results, but floor paints have not proved satisfactory.

Paints.

254. In some canneries, however, a protective paint, a synthetic red oxide primer, which resists steam and fruit acids, is widely used to cover steel surfaces which are liable to be occasionally wetted by fruit juices. It is used, for instance, to prolong the life of the spiral-cut rollers of the fruit graders and the link chains and spacing rods of the tunnel cooker.

Roofing.

255. A high-pressure cemented asbestos, known as " Asbestine ", has been found more satisfactory for roofing than corrugated iron, owing to its resistance to corrosion by sea air. Where galvanised iron is used, it is first painted with the red oxide primer before being coated with aluminium.

Glass and Wire Gauze.

256. Departments where cut fruit or juice are handled are sealed off from the rest of the cannery by partitions of glass and fine wire gauze, and the overhead inspection lamps are sometimes also shielded with fine gauze to prevent dead insects falling down on to the exposed cut fruit in these rooms.

Factory Layout.

257. The canneries are all well lighted, well ventilated and well planned. From the foregoing it must be apparent that production is organised in parallel lines in three distinct stages: (*a*) fruit preparation, (*b*) processing, and (*c*) packing, with, of necessity, two distinct breaks in the process, after grading and again after cooking the product.

258. As on the plantations so also in the canneries, the industry is 90 per cent. mechanised, with only fruit trimming and fruit grading still demanding the personal touch. Conveyors swiftly carry the whole, cut, canned or packed fruit through the process, thousands of feet of belting, chain, and rollers being used for the purpose.

259. But not only is the principal product, sliced pineapple, dealt with in this expeditious fashion; the production of subsidiary products is also properly integrated with the canning lines, so that there are no vast accumulations of waste awaiting treatment. The importance of this may

well be realised since, during the peak two months, when 75 per cent. of the total crop is handled, approximately 375,000 tons of pineapple waste have to be continuously and expeditiously converted into pineapple juice, crush, bran, pure sugar solution and citric acid before it deteriorates.

260. The largest cannery has a total covered floor space of 37¼ acres. Messengers and foremen use motor scooters, and these, together with the electric trucks and haulers, present a traffic problem which is solved by the provision of painted safely lanes for pedestrians and by strip-painting all stanchions, uprights and moving vehicles so that they catch the eye. There is however very little movement of staff or employees within the factory since mechanical aids are used wherever possible. Verbal communication between departments is by loud speaker and telephone.

SECTION D : SUBSIDIARY INDUSTRIES AND BY-PRODUCTS.

SECONDARY PRODUCTS.

Fresh Pineapples.

261. The shipment of unrefrigerated fruit from Hawaii to the Pacific Coast has never been very successful, nor has the development of refrigeration facilities resulted in a large trade in fresh fruit. In 1946 the total shipments still only amounted to 22,103 crates, representing but a tiny fraction of the annual crop of pineapples in Hawaii.

262. Nevertheless fresh pineapple is regarded in non-producing countries as a luxury in quite a different class from the canned product. It is apparent that the losses which occur during storage and when the fresh fruit is exposed for sale are the principal obstacle to the development of volume business.

Fresh Frozen Pineapple.

263. The new process of quick-freezing at low temperatures, otherwise known as deep-freezing, may have a profound effect on the fortunes of the pineapple industry. By this process it is now possible to offer, in convenient small packages and at a fraction of the cost, the choicest part of a plantation-ripened pineapple without any of the losses which are incidental to the trade in fresh pineapples. This new product is superior to voyage and shop-ripened pineapple because the original flavour, texture and freshness of a fruit which has been ripened on the plant are retained. Also the contents of each package consist only of selected pieces of fruit from the bottom half of each ripe pineapple. No preparation is necessary; the fruit is ready to serve, and there is no waste.

264. It is not considered, however, that fresh-frozen pineapple will ever replace the canned product. Deep freezing and canning were stated to be complementary and not competing industries because the canned product can be kept until required, whereas frozen pineapple must be consumed within a few hours of purchase unless kept at 0° F. in a refrigerator. The flavour of fresh and canned pineapple are also so different that they are actually different products, like fresh and canned salmon.

265. Investigations on the application of this new process to the pineapple industry were begun in Honolulu

in 1944, and, two years later, a pilot processing line for the production of fresh frozen pineapple was in regular operation.

266. The process is roughly as follows. The ripe fruits, freshly received from the plantation within 24 hours of cutting, are washed, peeled, and cored. The fruit cylinders are trimmed, as previously described, before being mechanically cut into 1 in. slices. The emerging slices are pushed mechanically along a half-round stainless steel channel in front of a group of girls who remove the whiter, less sweet slices, and the thin and broken slices, leaving the full yellow slices to slide on.

267. These selected slices are then forced, automatically, 12 at a time, through a segmented cutting die, by means of a reciprocating ram. This reduces them to segmented chunks, or near cubes of 1 in. size, which provide an attractive pack. They are measured into cans, check-weighed on a plus-minus scale, a weak syrup is added, and the filled can is placed on a belt and carried on to the packing table.

268. Here the contents of each can are emptied into a cellophane bag which is inside a shallow cardboard box. This box is then placed on another moving belt, the cellophane bag is automatically hot-sealed, neatly folded down by hand, and finally the box is gummed, closed, sealed and wrapped automatically.

269. These flat, 1 lb. packages are neatly packed into shallow metal trays which are stacked, one above the other, on a rack fitted with wheels. The whole stack is then moved to the chilling room where the temperature of the packages is reduced in the ordinary way to near freezing point.

270. The quick-freezing process follows next. Its object is to secure rapid heat transfer, so that the temperature of the pineapple is lowered from that at which initial ice formation occurs (about 28° F.) to that at which ice formation is complete (about 15° F.) within 30 minutes. Such rapid freezing is achieved by exposing the large surface of the thin flat packages to moving air at a very low temperature (—30° F.).

271. Special deep-freezing cabinets are used, consisting of a tier of freezing pipes between which the sheet metal trays, each containing 24 1 lb. packages, are inserted. The

packages are cooled by forced draught and by conduction through direct contact with the refrigerating pipes. When vegetable tissue is rapidly frozen in this way, microscopically small crystals are formed and these are uniformly distributed through the product, whereas when the fruit is frozen slowly, as in ordinary refrigeration, the ice crystals are large and not uniformly distributed. Large ice crystals shatter the structure of the tissue, the cells are forced apart, water is lost from the product, and it becomes dehydrated.

272. The deep-frozen product is warehoused at —10° F., and taken to the docks in special refrigerator vans carrying 960 packages at a time. The product has to be distributed thereafter through an organised distribution network to the ultimate consumer in such a way that it is kept, more or less continuously, at or near a temperature of 0° F. It is, of course, not a sterile product and, once removed from zero or vicinity temperatures, will decay just like the fresh fruit.

Dried and Candied Pineapple.

273. Other methods of preserving cut pineapple, in addition to canning and freezing, are drying and also preserving in sugar. There is no record of any exports of dried pineapple or pineapple jam from Hawaii, but a small quantity of preserved pineapple is manufactured as a subsidiary product of the canning industry.

274. Preserving in sugar is normally effected by boiling and soaking chunks or slices of fruit in a succession of hot sugar syrups of gradually increasing strength, starting at about 30° Brix and finishing at about 72° Brix. Candied or crystallised pineapple is obtained if the chunks of fruit are finally immersed in hot supersaturated sugar solutions. and then allowed to drain on a stainless steel grill.

Pineapple Juice.

275. Pineapple juice is no longer a minor product of the Hawaiian pineapple industry, since over eight million cases of this product are now produced in Hawaii and consumed annually in the United States in competition with tomato and citrus juices. The secret of the success of this important second industry has been colourful advertising. Lack of advertising previously resulted in a vast accumulation of unsold stock.

276. The juice has to be of full flavour and bouquet and so only the choicest fruit is used. The small ratoon fruits which are too small for canning, but have the most delightful flavour, are particularly suitable. These are allowed to ripen on the plant and are processed within 24 hours of cutting. Bruised and very ripe fruits which are unsuitable for the production of cut fruit are also used. Beverage juice can also be obtained from the strainings from the wet pulp which is eradicated from the inside of the shells of larger fruits as the white flesh nearest the skin is always of better flavour than the deeper-seated flesh.

277. The whole fruits are sent through a rotating circular knife and the emerging cylinders of fruit are mechanically quartered at the rate of 300 per minute. The quarters are broken down in a dog-tooth disintegrator, and the resulting pulp is heated to 170° F. by passing it continuously on through a steam jacketted pipe on to the screw press where the juice is extracted.

278. The extracted juice is screened through a stainless steel screen to remove coarse fragments of fruit; then it is sent through pulpers to reduce the particle size of the yellow sediment, and finally it is allowed to settle in a 1,000 gallon stainless steel tank. Beverage juice is not fine-filtered, no sugar, colouring matter or preservative is added and it is apparently neither chemically-treated nor de-aerated.

279. The juice is processed in Hawaii in three different ways. In one, the juice is heated to 170° F. in batches in jacketted stainless steel kettles, filled hot into sterile cans which are closed at once in the ordinary way. In another, the juice is put into the cans when it is slightly warm; the filled cans are closed by a vacuum seamer and heated to 170° F. in a continuous rotary cooker. This method, it is claimed, prevents the loss of fruity esters during sterilization. The latest method is flash pasteurisation, *i.e.* short, high-temperature sterilization. In this process the juice passes continuously, as a thin film, through a stainless steel coil surrounded by a jacket of steam. The juice attains a temperature of about 190° F. in its 2 minutes passage down the coil. It is filled at about 140° F. into sterile cans, using a vacuum closer.

280. It is important that the empty cans should be carefully washed to remove grease, dirt and insects, possibly adhering to the surface of the tinplate. This is effected by

spraying the inside of each can with hot water and drying it with steam as each passes, in succession, along the conveyor belt to the juice filler.

THE PROBLEM OF PINEAPPLE WASTE.

281. Cut fruit is, of course, the basis of the pineapple canning industry, and the yield of sliced pineapple in Hawaii appears to be about 16 per cent. of the weight of the whole fruit. The exact amount in any country depends on the size, shape and quality of the fruit, the type of cut, *i.e.* slices, cubes, dice or tidbits, and the efficiency of cutting. The residue, the shells, tops, tails, cores and trimmings, which normally constitute over 80 per cent. of the fruit, was formerly regarded as waste.

282. In aggregate, this waste amounted in Hawaii to an enormous quantity of material. As the industry grew, the problem of its disposal became increasingly serious, since it was a costly, unsatisfactory and troublesome business. The so-called waste was tipped into ravines or swamps, or else taken far out to sea and dumped. Sometimes, too, it constituted a public nuisance. To-day, when the total amount of waste is well over 500,000 tons a year, all of it is profitably utilised and nothing at all is wasted.

283. The introduction of the eradicator made it possible first of all to increase the yield of canned products to over 50 per cent. of the weight of the fruit, mainly through the production of pineapple crush and the juice strained from the pulp. A further 25 per cent. was also scraped from the skins and recovered in the form of speckled pulp from which is expressed the juices used for the preparation of canning syrups.

284. The green skin, constituting the remaining 25 per cent., offered a more difficult problem. It was very wet; the expressed juice was rank and bitter and apparently useless; and it was uneconomically expensive to dry in order to use the fibrous residue as boiler fuel. The skins were unsuitable as a cattle feed, except in small amounts, because they induced diarrhoea and other disorders. The high moisture content and the development of acidity during the decomposition of this wet waste prevented its utilisation as compost or its direct return to the soil as an organic fertiliser.

285. It had been noticed that the ravines into which this material was dumped were much frequented by mynah

birds and bees. The birds would remove the black surface layer and enthusiastically devour the yellow slimy pulp beneath. Straying cattle too were habitually to be discovered at these heaps, feasting themselves into a state of intoxication. Thus was the idea born that pineapple skins could be converted into a silage or rough feed for dairy cattle.

286. It had been known, of course, that alcohol and vinegar could be produced from the bitter skin juices, but as both of these products could be more easily and cheaply obtained from other sources, only in very exceptional circumstances was this subsidiary industry considered worth while for the pineapple canner.

287. Finally, as a result of years of patient research, a process has now been evolved for the production of pure cane sugar solutions from these bitter juices, and the residual pineapple meal is now dried and converted into a sweet bran for use as a cattle feed.

PINEAPPLE BY-PRODUCTS.

Pineapple Crush.

288. Crushed pineapple is derived from two sources; from the eradicated white pulp, freed of all specks, which is ejected by the Ginacas, and from the faulty and broken slices rejected from the packing lines. The material is shredded in a dog-tooth disintegrator, or else finely chopped in a dicer, and the resulting wet material freed of surplus juice by straining it through a stainless steel screen, usually a continuous, rotary machine.

289. The pineapple crush is pumped into steam-jacketted stainless steel kettles and heated, with continuous stirring, to 195° F., generally with added sugar. It is then filled into cans, sealed and cooled. In the case of the large A10 or 1 gallon cans, the product sometimes receives a further 4 minutes cook in the can so as to sterilise the fruit in contact with the cold unsterilised can surface. As an alternative the cans may be hot spray-washed to clean off any spilled crush and prevent corrosion of the cans.

290. Crushed pineapple is sold mostly in sweetened form. The pack in 1946 included 1,845,171 cases of A2 cans, 615,844 cases of A1 cans of sweetened crush, and 541,085 cases of A10 cans of unsweetened crush. The total of all packs of crush amounted to 3,560,000 standard

Hawaiian fiberite cases. The profitable disposal of this vast quantity of by-product, as for the juice, demands expert salesmanship and advertising.

Alcohol and Vinegar.

291. Only one company, with related interests in the production of sauces, pickles and chutneys, is engaged in the production of alcohol from skin juices for subsequent conversion into vinegar. During the war, when all available cargo space on ships was required for war material, it was also a profitable business to convert this alcohol into gin for local sale in the Islands.

292. Pineapple juices contain variously between 9 and 12 per cent. of sugar and they can be converted into solutions containing between 4 and 4½ per cent. of ethyl alcohol. This very dilute solution of alcohol is concentrated in a fractionating still to the desired strength, and the resulting solution of alcohol is then converted into vinegar by contact with beech shavings in wooden tubs in the normal manner, or it is redistilled either to produce industrial alcohol or with juniper to yield gin.

Citric Acid.

293. The skin juices contain also something less than 1 per cent. of acid, principally citric acid, which it is necessary to remove from the solution. The juice is treated with carbon and Kieselguhr or fullers earth as a filter aid and then clarified by filtration or by centrifugal separation. The clarified juice is neutralised with milk of lime and then boiled and the resulting precipitate of calcium citrate is continuously removed by a Sweetland rotary filter, while the juice passes away.

294. Citric acid is recovered from this white precipitate by decomposing it with sulphuric acid. Unwanted calcium sulphate is then removed by filtration, and a clear solution is obtained which, after concentration and crystallisation, yields large glassy crystals of citric acid. The product is packed for export in bags of special acid-resisting fibre inside wooden boxes.

295. This is not a commercial means of producing citric acid, but is a process which is incidental to the refining of the bitter skin juices. The annual output is a few hundred tons and exports are valued at about $170,000.

Canning Syrup.

296. The rank yellow juice which leaves the rotary filters contains malic acid which is not removed by the lime treatment, and also various mineral salts, organic esters, proteins and other organic compounds in trace amounts. All these undesirable elements are removed and the juice is converted to an ordinary weak sugar solution by the new ion-exchange process. This sugar solution is finally concentrated in quadruple-effect evaporators and then distributed to the canning lines in any required strength as canning syrup.

297. The ion-exchange process is a sort of batch filtration process using special synthetic resins to absorb the anion and basic kation elements constituting the undesirable elements in the juice. The plant, which is rubber-lined throughout, consists essentially of a battery of absorption towers and a set of tanks, containing solutions for regenerating the resins. The tanks are directly connected and interconnected by a complete system of coloured pipes to give different lines of flow, depending on what stage the process has reached, and whether the absorbent resins in any of the towers are in need of regeneration.

298. The treatment is completely automatic. The process is controlled from a bridge by a system of dials. lights and buttons. A warning light indicates the need for a change of treatment or for the regeneration of the resin in any one of the absorption towers, and a selection from a battery of buttons operates the necessary automatic valves. There is a set of continuous recorders for providing a complete record of the acidity and conductivity of the sugar solutions as they pass through the plant.

299. This remarkable process was evolved in a pilot plant, costing approximately $100,000, and capable of treating 10 gallons of juice per minute. This was the forerunner of the full-scale commercial plant, now installed, which cost $1,500,000 and is able to deal with 300 gallons per minute. It is claimed it will produce the equivalent of 4,000 tons of cane sugar every year from the hitherto useless skin juices.

300. Such an installation, it is said, requires a cannery turnover of at least 60,000 tons of fruit a year to justify its existence as an economic proposition. Other essential considerations are the current price of sugar and the cost

of the expensive resins, as there is a working loss of 20 per cent. per annum owing to size reduction during washing and regeneration. Against these factors must be offset the cost of pineapple waste disposal by dumping.

Cattle Feeding Stuffs.

(*a*) *Pineapple Bran.*

301. After the pineapple skins have been ground in a vertical shredder and twice-expressed in a screwpress to extract as much juice as possible, the resulting meal is said still to contain moisture equal to half its weight. This excess moisture is removed by passing the ground meal through a rotating tubular drier (or cement drier) in which a tongue of flame from an oil-fired furnace dries the rain of meal as it passes down the tube. The resulting product, known as pineapple bran, is crisp and sweet and convenient to handle as a commercial commodity.

302. On the basis of analyses carried out in Hawaii the average composition of the product is roughly:—water 10 per cent.; protein 3½ per cent.; fat 1½ per cent.; sugars 20 per cent.; fibre 20 per cent.; starch 20 per cent.; other nitrogen-free matter 22 per cent.; and ash 3 per cent. Regarded as a feeding-stuff, it is high in sugar, fairly high in fibre, and low in protein.

303. Pineapple bran is essentially, therefore, an energy-producing food, and as such is fed to work-animals, *e.g.* horses and mules on the plantations, together with corn, wheat bran, molasses and panicum grass. Being low in protein, it needs to be supplemented with high-protein feeds when fed to dairy cows which are said to develop a marked fondness for it. As a feed for fattening pigs, ground pineapple bran can be used advantageously, but naturally it is not the equal of corn or barley. It makes an economical feed with tapioca root, rice bran and coconut cake.

304. Pineapple bran is in great demand in the Islands and is likely to continue so as long as the price remains low. The total value of this former waste product, used as cattle feed since the initial trials were carried out, is said to be about $8,000,000. Three or four canneries are now engaged in its production, the largest producing 6,000 tons per annum. Four tons of waste, it was stated, require 4 gallons of fuel oil to produce about a ton of dry bran.

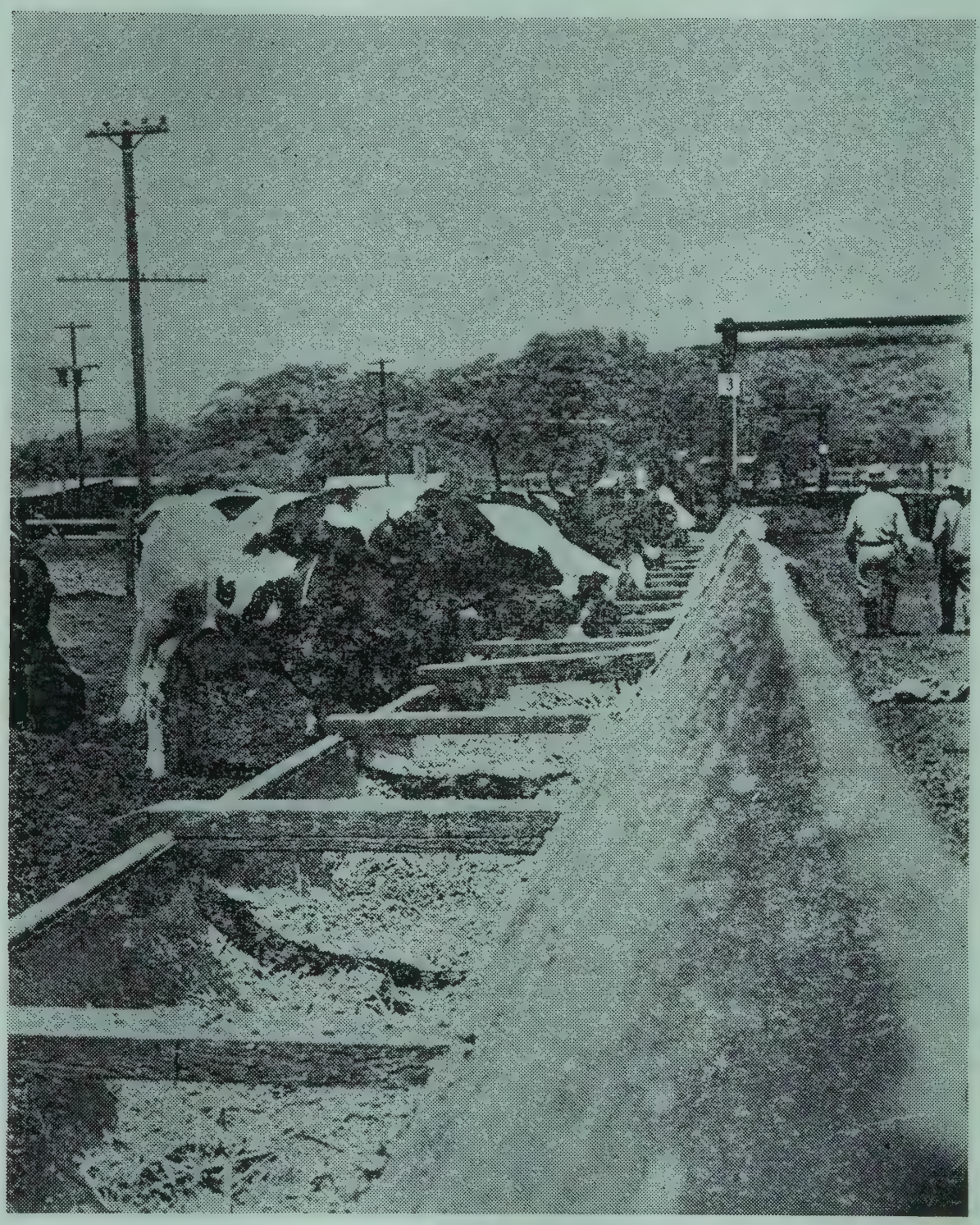
* LABELLING AND CASING.

A mechanical tray unloader feeds the cans in a triple stream to the labelling machine (1,300 cans per minute). Subsequently a plunger delivers 12 cans at a time into standard fiberite cases.

WASTE UTILISATION.

Pineapple silage,—a sweet-sour pickle with an attractive fresh smell—is produced from pineapple skins by anaerobic fermentation in sealed pits.

PLATE 23.



WASTE UTILISATION.

A dairy farm with 1,000 head of cattle is based on the pineapple industry. The rough feed used contains 75 per cent. of pineapple silage.

305. From the point of view of the canner, the manufacture of bran at present low prices is not regarded as a very paying proposition. The margin of profit is said to be so small that ocean shipment is no longer feasible. The process appears to be regarded solely as a satisfactory method of disposing of the waste which does away with the expense and trouble of carting and dumping it. In spite of the heavy initial expense of the plant, its cost has been recovered in past years and the maintenance and repair charges are now low. In short, the process pays for itself, a nuisance has been eliminated and a useful commodity has been produced from what would otherwise be a liability.

(*b*) *Pineapple Silage.*

306. The smaller canneries are not large enough to justify the expense of a bran plant. On the smallest plantations the raw wet waste is simply tipped into pits on either side of a Decauville track. These pits are sealed and left for three or four years; after this, the black surface layer is removed and discarded, and the slimy pulp is used as a feed for dairy cattle.

307. Where a cannery is situated in a town area and many thousands of tons of wet waste would have to be carried annually for several miles beyond the town area, it halves transportation costs to crush and press the skins, use or discard the bitter juice, and transport half-dried meal to silage pits. Decomposition is accelerated because of the greatly reduced moisture content and total acidity of the material, and the silage is ready a few months after dumping.

308. The silage pits are best situated on land adjacent to the dairy farm. Trenches, about 15 ft. wide and 15 ft. deep, are cut through a mound well above the surrounding land so that the bottom of the trenches do not flood, and the juices from the rotting pineapple waste can drain freely away. The bottom of each trench is filled to a depth of 4 ft. with lallang, and the trench is gradually filled up with daily additions of waste pineapple meal brought by road from the cannery. When it is full, a heavy caterpillar tractor is used to crush and compress the waste, and beat out the air. Then, finally, the silage trench is sealed with tarpaper and covered with earth and sods.

309. In consequence of anaerobic decomposition, or fermentation out of contact with air, the coarse, indigestible

and bitter pineapple waste is converted into a soft, digestible pulp with a fresh alcoholic smell and a sweet-sour flavour. After only two or three months' storage the tarpaper is removed, the superficial black layer is scraped away, and the silage is scooped up out of the trench by a caterpillar shovel which picks up a load of pulp in one motion and carries it away to the cattle mangers.

(*c*) *Pineapple Tops.*

310. The value of pineapple tops as another rough feed for cattle has been realised by livestock experts in Hawaii. These tops are said to be superior to pineapple bran, whether they are chaffed, fine-chopped or ensiled. Chopped pineapple tops are stated to contain about 50 per cent. more protein and fat than Napier grass, and less than half as much crude fibre; when fed to cows they have resulted in better yields of milk than with the grass.

311. The smooth Cayenne pine, as previously stated, has a large crown which is punched off when the fruit is harvested. Since the crop is so markedly seasonal these tops generally need to be ensiled for later use. They constitute about 7 per cent. of the weight of the fruit, and, on this basis, it is estimated that the potential supply is about 42,000 tons annually. It is stated that the average cow can consume about 1 ton of pineapple tops per month, so that the crowns would constitute a rough feed for 3,500 cows if all available supplies were collected.

312. The original silage trials were carried out at the University of Hawaii in a wooden stave silo, (8 ft. high by 17 ins. in diameter), which was filled with chopped pineapple tops together with 5 per cent. of molasses. Only 65 days after filling, the top surface layer (1.3 per cent. of the total) was removed and the silage was ready for use. The average composition of the resulting silage was:—water 84 per cent.; protein 1.6 per cent.; fat 0.6 per cent.; fibre 3.6 per cent.; ash 1.5 per cent.; and nitrogen free matter 8.7 per cent.

UTILISATION OF PINEAPPLE FEEDING STUFFS.

313. This account of feeding stuffs derived from the pineapple requires to be completed by a brief account of a large dairy farm, near Honolulu, where these feeds are largely used. The farm is a million-dollar concern, having

1,000 cows, 8 bulls, and also pigs, all kept continuously in pens. The cattle imported are Holsteins, Brown Swiss and Jerseys; serving is by artificial insemination; and milking is largely mechanical. They are kept in stockades in groups of eighty, based on health, weight and individual milk records, and fed accordingly.

314. The stockades are situated on both sides of a narrow road which is bordered by two parallel mangers, each about 100 yards long. The silage and other rough feed is brought in by caterpillar scoop or by lorry and shovelled direct into the mangers. This feed is made up of 75 per cent. pineapple waste silage and 25 per cent. elephant grass, chopped pineapple tops or pineapple top silage. When silage is short, the rough feed used is 50 per cent. pineapple bran and 50 per cent. grass, though silage is preferred to bran whenever it is available.

315. Twice a day, in groups of eighty, the cattle pass in single file down runways to the washing and milking barns. While they are being washed and scrubbed, and having their teats sterilised, they are fed on concentrates consisting of a mixture of wheat bran, soya bean meal, chopped alfalfa and 5 per cent. pineapple bran to give bulk.

316. Fattening pigs on the same farm are fed on a mixture of pineapple silage, chopped pineapple crowns and tapioca waste. It was found that if they were fed on silage alone they turned red, and, in any case, this feed alone is deficient in starch and proteins.

317. The economy of the farm is completed by the fact that all urine and manure is recovered and applied to an adjacent 20 acres of land where elephant grass is grown. The corrals have a flat macadamised surface which is covered with saw-mill waste, and at regular intervals the surface is scraped clean by mechanical road graders. It is claimed that by ample watering, heavy liming and unusually heavy manuring, this land yields 190 tons of wet grass per acre per annum.

318. This farm is, therefore, essentially founded on the fact that the pineapple industry can provide a very cheap feed for cattle. Semi-dried waste was being delivered at $6 per ton, and pineapple bran at $30 per ton, loose, and $55 per ton in bags for storage. The total annual intake of raw pineapple waste alone is 4,000 tons for 1,000 cows which are said to produce an average of 14 quarts of milk a day each.

SECTION E—RESEARCH, TECHNICAL INSTRUCTION, AND CONTROL.

Research.

319. Research has played an increasingly important part during the last three decades in the improvement of the pineapple canning industry in Hawaii. Its steady growth, efficiency and pre-eminence, in the face of serious production and financial difficulties, are primarily due to exhaustive research into the problems of planting, processing and can-making by a large force of scientifically-trained men and women, and by the careful planning and strict control of field and factory operations by qualified technicians in managerial and supervisory positions. The object of all this technical work has not merely been to provide an answer to current problems, for it is considered to be of equal, if not greater importance, to anticipate trouble and to have the answer ready when an emergency arises. There is, in this industry, a dynamic, unceasing, and restless urge to discover new methods and new products; to secure ever greater efficiency; and to initiate and show the way, and not merely keep abreast of new developments.

320. What benefits has all this research contributed to the industry? Some results are obvious and immediate, and can be readily evaluated in terms of dollars. Others are less obvious in that they merely ensure that the plantations shall maintain their standard of productivity and remain healthy. Yet this work is probably of greater importance than the other, because it is to soil conservation, pest control work, the maintenance of soil fertility, and to similar work of a protective nature that the industry owes its survival.

321. In the United States, industries spend between ½ to 6 per cent. of their revenue on research, depending on the nature of the industry. In the case of the pineapple industry, the overall expense on institutional, company, field and factory research, carried out in Hawaii was estimated to be nearly 1½ per cent. of revenue, about $3 per ton of fruit, over $30 per acre, or about 20 cents per Malayan standard case. The amount can only be guessed, but it is probably more than $2,000,000 for a total acreage of only 63,000 acres of pineapples, which yields, however, a revenue of about $140,000,000 per annum.

322. It is appreciated that the vast sum spent on research is an insurance for the continued existence of the industry and for its ability to compete successfully with

similar industries operating where wage rates are lower. It was stated by canners, growers, and others, that research is the last thing that would be cut if the necessity for retrenchment arose, and there has never been any objection from any individual firm regarding its contribution to the cost of research.

Research Organisations.

323. The National Canners Association of America is primarily a research organisation, formed in 1907 to improve canning methods and the products of the canning industry, and to engage in fundamental research into the nature of canned foods. There are separate committees of the Association to cover scientific research, raw material standards, consumer complaints, public relations, canning legislation, standards of quality, standard can sizes and labels, specifications, statistics and technical information. Membership is open to any person, firm or association engaged in the preparation or canning of foods. The present membership fee is 0.6 cent per case on seasonal products such as pineapples.

324. The Association maintains research laboratories at Washington, Seattle and San Francisco, which together have a staff of more than 30 scientifically-trained men and women. These laboratories carry out investigations of the fundamental principles that govern canning. This work has included the study of heat penetration into canned foods of different kinds, heat resistance of various spoilage organisms, calculations of processing time and, detailed technical descriptions for processing individual products. In the technological field it has covered the study of processing operations, the examination of new equipment, research work on the profitable disposal of waste products and the prevention of nuisance. On the nutrition side there has been a very extensive investigation of the nutritive value and wholesomeness of canned foods, with particular reference to their vitamin and mineral content. The Association supported a systematic study of food poisoning and dispelled the ptomaine-poisoning myth. It has provided information to canners which will effectively protect the public against the possibility of botulism or bowel complaints caused by improper methods of canning. It maintains a motorised service unit to provide service to individual canners, and the trailers used are fully-equipped laboratories for the examination of canned foods.

325. The American Can Company has served the canning industries of Hawaii for nearly 40 years; it has not only made and sold cans to the pineapple canners, it has also entered into the technical problems of the industry and contributed to their solution. Naturally this company is primarily concerned with the nature and quality of tinplate and lacquers, the invention of new mechanical devices, the efficiency of can-making machines, and with research work directed towards the production of the perfect can and the elimination of faults in can-making, food processing or can-closing, which would result in spoilage and consumer-complaints.

326. Scientific work on the agricultural side first began in 1914. Today, the Pineapple Research Institute, situated in the suburbs of Honolulu, on land adjacent to the University of Hawaii, is financed and supported by the Hawaiian Pineapple Growers' Association.

327. There is no fixed cess on the industry. The Director prepares an annual budget each year, based on the research programme for that year, which may require new staff, or special equipment and materials. If a new problem unexpectedly arises during the year demanding immediate action, a special board meeting is called to approve a supplementary vote. The annual vote thus fluctuates, and is not in any way prejudiced by previous expenditure. It is the duty of the Director to bring new problems to the notice of the Board and to ask for the necessary money to deal with them. He must not suppress or defer problems for reasons of economy without reference to the Board.

328. The Institute has a staff of 17 scientifically-trained men and women, and comprises laboratories in Honolulu and a field experiment station of 80 acres in the heart of the pineapple country. There are ten divisions of the Institute, *viz.* chemistry, entomology, pathology, agronomy, genetics, physics, and soils chemistry, plant physiology, agricultural engineering, meteorology, technical information, and statistics.

329. The Pineapple Research Institute has been responsible for the classic researches on the control of the mealy bug (which at one time threatened to wipe out the entire industry), on the discovery of new soil fumigants to destroy obnoxious soil organisms, on the use of diesel oil as a base for chemical mixtures used to suppress noxious weeds, and on the correction of the cumulative deficiencies

of major, minor and trace elements and of organic matter in soil which has been repeatedly planted and replanted with the same crop over a very long period of years. In its long and patient search for the perfect pineapple plant it has produced, during the past 26 years, no less than 18,000 new hybrid varieties of pineapples by cross-breeding, and out of this work may come the pineapple of the future. A new variety cannot, however, displace the Cayenne easily or suddenly because of commercial conservatism and because it is difficult to multiply planting material from a few original slips. To-day, this Institute is finding a fertile field for research in the use of the new growth-regulating substances, the hormones, which have already resulted in the revolutionary changes in field practice, previously described.

330. It has no field branch and is purely a research institute. but by direct contact the staff extends to the growers, through demonstrations and trials, the results of its research. It is appreciated by the industry that the farmer type of grower is inclined to resent change and receives new ideas with apprehension, and so, in order to provide the dynamic force necessary to secure the successful application of the results of research, every plantation has on its staff at least one agricultural research graduate.

331. It is the policy of the Institute that its research officers shall maintain the closest possible liaison with their opposite numbers on the plantations. From time to time, joint conferences are arranged to review evidence, to debate specific problems, and to decide research or plantation policy. The plantation technicians receive reports of the progress of small-scale experiments and see for themselves the progress of the trial plots at the pineapple experiment station. On their own initiative they may start middle-scale or pilot trials on their plantations without waiting for the final results of the small-scale experiments, and the Institute officers are available to advise on and watch the progress of these plantation trials. In this way, the long time-lag, which normally occurs between the birth of an idea and the final publication of the results of the investigation, is obviated.

332. In addition, the pineapple companies individually support experimentation, within their own organisations, to elucidate practical planting or processing problems, or both. The largest company has a complete research

department, astonishing both in its size and scope. This department is divided into three divisions: (*a*) processing and by-products, (*b*) plantation and ranches, and (*c*) inspection and education.

333. The first is concerned with: (1) improvements in processing to obtain improved quality, greater efficiency and reduced working costs, (2) the evolution of new processes and new products, and (3) the economical disposal of the waste products of the industry. The staff of this division includes a technologist, a biochemist, a bacteriologist, two assistant chemists and about twenty other workers.

334. The second division deals with: (1) the questions of trash utilisation, soil conservation and re-afforestation, (2) clonal selection, (3) crop rotation with possible alternative crops, (4) planting problems and livestock maintenance, and (5) rain-making, irrigation and crop forecasting, based on meteorological records. The staff of this division includes a horticulturist, a plant physiologist, a geneticist, two agronomists, and a field superintendent. There is also a soil conservation adviser on the headquarters staff.

335. The third division is responsible for inspection and the publication of daily reports on the quality of the fruit received, the operating efficiency in the cannery and the quality of the final products. It also supplies technical information and photographs to the staff and to the public relations department of the company, and maintains a library of technical literature, patents and statistics. The staff of this division consists of an administrative assistant, a photographer, a librarian, an artist and about twenty other workers.

336. Thus besides its director, this department has a total staff of 15 technicians and about 100 other workers. The company maintains 12 laboratories at the cannery in Honolulu, and 2 field laboratories on its plantations. The research laboratories include nutrition, bacteriology, chemistry, physiology and genetics; there is a laboratory for hazardous work on insecticides, for high pressure investigations, for frozen food trials, for testing and evolving recipes, and for control and inspection work; there is a high-temperature storage room and an extremely well equipped photographic laboratory. The pilot plant of the

new ion-exchange process is also operated by this department. Finally, there is a large auditorium for exhibitions, conferences, cookery demonstrations, technical lectures, staff committee meetings, worker-instruction and film shows.

TECHNICAL INSTRUCTION.

337. Friendly and understanding contact is maintained between the management and the staff by inviting the intelligent co-operation of the workers. In every possible way they are encouraged to feel that they are responsible factors in the organisation, and that their welfare is directly linked with the continued progress and prosperity of the industry. For this reason, suggestions from the employees for new mechanical devices, for improvements in handling and processing, to give protection from accident and to improve the working conditions and welfare of the employees are regularly considered and adequately rewarded, according to the value of each proposal, by a committee on which the workers are represented.

338. There are conferences, attended by the plantation or cannery supervisors and the workers concerned, at which new proposals are submitted, evidence is considered, decisions are made, and appropriate instructions are issued. When any change or new development is about to be introduced, the workers attend film shows and lectures to receive proper instructions and ensure their complete sympathy and understanding of the idea and of the intention.

339. This is supplemented by a system of illustrated instruction leaflets issued by the research department and by the provision of visual standards of quality for ready reference in the cannery. This is considered to be necessary because the quality of the fruit varies seasonally and from different fields. It is essential to ensure in this way that a uniform standard is adhered to throughout the cannery, otherwise it is inevitable that gradual and imperceptible fluctuations in grading standards would occur, and that the relations between the workers and their supervisors would be strained by misunderstandings and hectoring.

Visual Standards.

340. Photo standards are provided to describe the shape of the fruit. These are used as the basis for selection

work and to describe the fruit reaching the cannery from the field. The standards and codes are as follows:—

Approved :	Cylinder; (C)	Square; (S)	Oval; (O)	Long Oval (LO)
Not approved :	Conical; (CO)	oval cone; (OCO)	long cone; (LCO)	long oval cone (LOCO)

341. Realistic models of whole fruits, fruit cylinders, cut slices and broken slices are used by this company to assist the fruit harvesters to conform to a prescribed standard of ripeness, the fruit graders to pack to uniform standards, and the girls, working on the inspection line, to record the fruit correctly on the basis of visual standards.

342. It was found that plaster of Paris models did not give either sufficient smoothness and detail, or the correct depth of colour brilliance and translucency. Perfect models have since been produced by making jelly casts of the objects, using agar, obtained from seaweed and marketed under the trade name of "Plastro". Paraffin wax of high melting-point is then poured into these jelly moulds and the resulting wax cast is trimmed up by dental tools. The basic colour, an oil-soluble pigment of red, yellow or green, is added to the wax when it is liquid, and colour variations are applied by brush after the wax has set.

343. Whole fruit models have been produced in seven shades of colour, ranging from red to deep green. These are used on the plantation to define the standard of picking as the skin colour of a ripe fruit is not the same for fields differently situated. In the cannery they are used by the fruit inspector to describe each fruit as it passes along the quality control line.

344. Cylinder models mounted on black velvet are similarly used to describe the colour and brilliance of the flesh of the fruit, approximately as follows:—

	Yellow	Pale Yellow	Whitish
Brilliant	BY	BP	BW
Dull	DY	DP	DW
Opaque	—	OP	OP

345. A set of similar models is used to illustrate blemishes, e.g. slightly bruised, severely bruised, brown spot, eye rot, glassy spoilage and pink discolouration.

346. A set of slices has been prepared to define the limits of the fancy and choice grades to prevent variation in the standards of packing due to seasonal and other fluctuations in the quality of the fruit received. There are also models of defects to be found in slices:—

Texture	:	somewhat open	;	spongy
Firmness	:	broken	;	damaged
Eyes	:	deep	;	seedy
Flecks	:	slightly flecked	;	markedly flecked
Core	:	displaced	;	over-large.

A transparent celluloid gauge is used to examine the slices.

CONTROL.

Quality Control.

347. In this cannery every consignment of fruit received is weighed and the following details are recorded:—harvesting gang number, field number, age of plants, date of picking, method of transport and date of receipt at the cannery. A sample of the consignment is diverted along a special processing line where it is expertly inspected and its quality recorded at various points in the process. Samples of the same day's work are also collected at random on the following day in the warehouse and these are opened and inspected in the control laboratory.

348. The sample consists of 100 fruits taken at random from one of the bins of a consignment. The fruits are first graded for shape and skin colour on an inspection belt, where one girl inspects each passing fruit and another records her findings, the results being expressed as percentages. The sample is then sorted into three standard grades of size; a man collects the three lots into baskets, weighs each lot, and also ascertains the average fruit weight of the whole consignment.

349. The baskets of graded fruit are brought to the quality inspection line. The smallest, or No. 3 grade fruit, the eradicated pulp and any fruit trimmings are shredded, pulped and weighed individually, the juice is extracted and its sugar/acid ratio determined in the control laboratory. The baskets of No. 1 and No. 2 size fruit are brought to the quality inspection line, a continuous line on which the fruits are cut, trimmed, sliced and graded, for girl inspectors to examine the cylinders and slices as they pass before them.

350. The fruit cylinder inspector rapidly describes the flesh colour and translucence of each passing piece of fruit while a second girl records; the trimmings, produced by four expert trimmers, are carefully collected and weighed; the resulting slices are inspected for internal defects and blemishes by a third girl inspector; and finally there is a team of three girls who sort the slices into fency, choice and standard grades, the yields of which are exactly recorded.

351. The results are collected and presented on two forms, one a brief report giving the important factors of quality of the consignment in the form of index numbers, and the other a complete report giving complete details of the fruit quality and defects and the grading and recovery rates. These details cover the shape, skin colour, degree of ripeness (internal), degree of bruising, and various blemishes and defects, all expressed as percentages, and also the yield of the various grades of cut fruit and of pine-apple crush, juice and canning syrup per ton of fruit which should be obtained.

352. The brief report is sent to the plantation supervisor by telephone immediately the figures are ready, so that prompt action may be taken to correct any faults in harvesting or handling the crop. The full report is issued by the research department to the administration and to the plantation and production departments. The object is to supply information which will serve to indicate any serious deterioration in the quality of the crop and in processing. If there is evidence of fundamental deterioration in quality, it is for the research department to investigate the problem and supply the remedy.

Physical Inspections.

353. Women inspectors, working on the processing lines, check the physical contents of the cans. They look into the cans before the lids go on and make sure that the contents are properly graded and that the number of slices is correct. They also watch the can rims for dents as this would be likely to result in an imperfect seam when the lid is put on. There is a further check in the warehouse where the contents of the cans are rapidly checked on a plus-minus scale.

Laboratory Inspection.

354. Finally after the cans have been cooked, sealed, cooled and placed in the warehouse, they still undergo one last check. Inspectors of the research department go into the warehouse regularly and take at random cans of each size and variety from the preceding day's pack, open the cans and grade the contents. On one end of every can is stamped the code number and identifying letters which tell the inspectors on which processing line, and on what day, the can was packed. No consignment is released until the laboratory has proved the product.

355. Two standards of grading are practised: (a) commercial, (b) technical, or grading by marks. The three commercial grades have already been described; technical grading is applied by a team of inspectors who record their markings in separate voting booths without any discussion or exchange of opinion. This method of sampling is based on psychometrics, and the results can, if necessary, be analysed statistically to ascertain their reliability.

356. Another activity of this control laboratory is the testing of canning syrups. It is considered that fruit packed in 1 gallon cans requires a different density of syrup from that used in the small A1 can, and that, similarly, there is a difference for slices, chunks, tidbits, crushed and fresh frozen pineapple. These variations necessitate the use of separate pipelines and since, in the height of the season, as much as 100,000 gallons of syrup may be used in a single day, the importance of regular sampling becomes apparent.

357. Sample boys, apprentices in the laboratory, make hourly trips to collect samples from the storage tanks and pipe-lines in buckets, each bearing a number to correspond with that of a tank or tap.

358. The sugar content of these samples is recorded and the daily average is held within a limit of 0.1 to 0.2 per cent. of sugar.

359. A similar hourly check is made of the beverage juice obtained from the whole fruit, and the samples are tested for suspended solids, sugar content and acidity, and the sugar/acid ratio is determined.

Factory Records.

360. In the production office continuous graphs are maintained of daily tonnage of fruit handled, average fruit weight, daily yield of cut fruit, daily grading out-turns, cost per ton of fruit and cost per case; all these keep the supervisor aware of the operating position in the cannery.

Selection Research.

361. Selection work is one of the most important activities of the research divisions of the various companies. Selection has materially improved the character of the varieties of Hawaiian pineapple, used for canning, and selected planted material is regarded as the real capital of the industry. Clonal selection appears to be more immediately profitable than the cross-breeding of different varieties to obtain hybrids.

362. Successful selection work, it is said, demands continuity of work by a single specialist, living among the plants over a long period of years. It is considered to be an impossible task to try to meet all the requirements of the perfect fruit at once, *viz.* cylindrical shape, large and uniform size, bright yellow flesh, full fruity flavour, firm texture, shallow eyes, small core, broad smooth leaves, regular fruiting, good resistance to pests and diseases, and an adequate yield of slips for its reproduction. This would lead to an excessive amount of recorded data, and would restrict the field so much that few, if any, plants, would possess all these features.

363. Selection work cannot be carried to a satisfactory conclusion if there are interruptions in its continuity, due to staff changes and promotions, if there is long-range control with unqualified assistants doing the actual work among the plants, or if the geneticist is chained to his desk through keeping too much recorded data when he should be out in the field. It was considered that selection work must be carried forward in stages by the same geneticist over a period of at least twenty years, and that although systematic recording is of course essential, he must reduce his office records to the absolute minimum.

364. The method adopted demands the selection, multiplication, and reselection of clones over periods of about six years each. The initial selections in the field are carried out by field labourers on the basis of plant virility and freedom from disease, or else the geneticist himself

selects plants on a visual basis. In this way 10,000 mother-plants may be selected in an area of 500 acres from 8,750,000 plants.

365. The slips collected from these rough selections are planted in the nursery and constitute the clones, and a record card, indicating year and plant number, is prepared for each. The details recorded of the initial clonal card are roughly as follows:—

Clone: (Year)/(Number).

Date of harvest:

Character of plant:	Basal slips (number) .....
	Suckers (number) .....
	Type of leaves
Character of fruit:	Weight (lbs.) .....
	Shape (eight photo standards) ..
	Skin colour (five grades) .....
	Flesh colour (five grades) .....
	Brilliance (three grades) .....
Defects and blemishes:	Broken core .....
	Brown spot .....
	Eye rot (tick off as required) ...
	Sunburn .....
	Glassy flesh .....
	Spongy .....
Total spoilage:	Slices rejected (percentage of Total) .....
Character of juice:	Sugar content (°Brix) .....
	Acidity (ccs. of .1428N-NaOH) ..
	Vitamin C (green dye reading) ..

366. After the first crop has been harvested and unsatisfactory clones rejected, the progeny resulting from the successive plantings of slips from the selected clones are simply averaged and tabulated on the other side of the card under the following heads:— clone number, number of fruits, average fruit weight and shape, while space may also be left to record the brix, acidity and vitamin C content of the expressed juice, if required.

367. The basis of the subsequent selections depends on the requirements of each plantation. It may be primarily for shape, for size, for quality, for resistance to disease, or for the purpose of arranging or concentrating

the harvest. Hormones have been used to increase the slip production, so as to obtain more planting material from selected clones. The following is a typical clonal specification where selection is primarily for shape:—

Shape of fruit	..	Cylindrical or square only.
Weight	..	From 2½ to 4½ lbs. only.
Number of slips	..	2 to 3 only.
Number of suckers	..	3 to 5 only.

368. Plantations have had to concentrate on selection for shape because the machine-cutting of the fruit has demanded a cylindrical fruit to give a satisfactory weight or yield of cut fruit cylinders; it is obvious that conical or barrel-shaped fruit cannot do this. Excessively small or very large fruits are also quite unsuitable for machine-cutting. Subsequent selection for size might specify a fruit weight between 4 and 4½ lbs. in size. Improved yields of up to 20 per cent. which are said to have resulted, reduced the cost of production during the war years when, owing to rising wages, the need became urgent.

369. From the foregoing account of research and technical control, it will be well appreciated that it has required an army of over a hundred qualified technicians working in the field, the factory and the laboratory and on the boards of these companies to achieve the present high pitch of industrial efficiency of the Hawaiian pineapple industry which started from the humblest beginnings.

SECTION F : ORGANISATION, STAFF, LABOUR RELATIONS AND THE COMMERCIAL SIDE.

370. The Hawaiian pineapple industry is said to be responsible at the present time for 85 per cent. of the total world production of canned pineapple products. It has reached this pre-eminent position from small and modest beginnings in less than 60 years through a dynamic policy of expansion, based on co-operative research, fostered by co-operative advertising, and soundly secured on the basis of inter-locking finance.

371. The following brief account of the organisation and the business side of the industry, which is by no means exhaustive or complete, describes how the industry arrived at its present position and indicates the probable trend of future developments.

ORGANISATION.

The Homesteaders.

372. The industry was started and developed, from 1891 onwards, by homesteaders or small farmers, following the establishment of a settlement of Americans from the United States at Wahiawa, a small village, about 25 miles from Honolulu, which to-day, some sixty years later, is still the centre of the biggest pineapple-growing area in the Islands. These homesteaders owned small-holdings of the order of about 25 acres each, which they operated on a family basis. Thus they had no labour problems, and could, if necessary, work longer hours than if hired labour had to be employed.

373. Homesteaders are to-day only a small and unimportant factor in the industry. It is estimated that about 5 per cent. of the total acreage is worked by small-holders; the remainder is all company-owned and company-operated. The Hawaiian Homes Commission has established a settlement of homesteaders on Molokai, and there are also scattered small-holdings on Kauai.

374. The existing small-holders appear to be mainly of Japanese, Portuguese, and Puerto Rican origin. They are said to be intelligent and industrious, but their families

have been broken up by the war and they are no longer able to operate their holdings on a family basis. Their educated sons and daughters can now find lucrative employment in the naval base, in the Services and in the shops, offices and factories in Honolulu. Now that they have to employ extremely highly-paid hired labour, their problems are considerable.

375. Under-capitalised and without modern equipment, they find it increasingly difficult to operate independently. If they do, their properties deteriorate; one after another they fail; they sell out and are given employment by one of the canning companies.

376. Otherwise, to be successful, they must enter into a close working arrangement with one of these companies from whom they receive advances to meet current expenses. They are instructed when to harvest their crops, are assisted with mechanical equipment, and are advised on the control of pests and diseases and on the conservation and maintenance of soil fertility.

377. Inevitably the requirements of modern industry demand such strict control. There is no question of accepting from small-holders mixed consignments of fruit of varying degrees of ripeness. The company defines the exact standard of ripeness at which the fruit is to be cut by the growers for delivery to the cannery the same day. Nor is the prescribed standard a fixed one, it may be varied according to field conditions and cannery requirements.

378. Nevertheless Government protects the small grower. The price he receives for his fruit is arranged on a sliding scale, linked to the current price of canned fruit, and if the canneries are unable to use fruit which is ready for harvesting, they must still pay for it.

The Canners.

379. The original canners were homesteaders who bought fruit from their neighbours, and all started in a small way. New canneries, one after another, opened up in rapid succession, and, in twenty years, no fewer than 19 packing companies were formed. In all, 27 companies have

figured in the short history of this industry; many failed; some were absorbed or amalgamated; to-day only eight remain:—

Company	Incorporated	Plantations	Canneries
Hawaiian Pineapple Co.	1901	Oahu and Lanai	Honolulu.
California Packing Corporation ..	1916	Oahu and Molokai	Honolulu.
Libby, McNeill and Libby	1909	Oahu, Maui & Molokai	Maui and Honolulu.
Maui Pineapple Co.	1921	Maui	Maui.
Hawaiian Canneries Ltd.	1913	Kauai	Kauai.
Baldwin Packers Ltd.	1923	Maui	Maui.
Kanai Pineapple Co.	1906	Kauai	Kauai.
Hawaiian Fruit Packers Ltd. ..	1932	Kauai	Kauai.

It will be seen that there are now 12 company-operated plantations and 9 canneries, based on 63,000 acres of pineapples.

380. The above are public companies, owned by many thousands of shareholders. The largest has 5,300 shareholders, two-thirds of whom live in Hawaii; the second largest, which is part of a United States canning corporation, is owned by 15,000 shareholders; the third largest, also part of a mainland corporation, by 28,000 shareholders. These three companies constitute approximately 85 per cent. of the total production.

Business Agencies.

381. In the sixty years of the existence of the industry, it has been found that the companies which have figured in its history were at the mercy of three unpredictable hazards which from time to time put the smaller and weaker companies out of business. These are:—

(*a*) crop failures,
(*b*) difficult labour relations, and
(*c*) severe fluctuations in market prices.

382. The uncontrolled production and the accumulation of stocks of other canned goods in America made it impossible for individual pineapple canners to gear produc-

tion to demand and operate economically on planned lines. The companies ultimately discovered that they needed solid financial backing, united action in legal and labour matters. and the mutual interchange of technical knowledge.

383. Furthermore, the territory is 2,000 miles from its principal market and the source of its mechanical equipment and supplies. In consequence, merchant houses came to be appointed as the advertising, selling and purchasing agents for the majority of the companies. These factors or agents now own stock in the companies, and conversely the plantation companies own stock in the agency houses.

384. As previously stated, only two of the companies have their roots in America, the remaining six are Island-owned and Island-controlled. They are part of an interlocking and mutually-supporting organisation covering sugar, pineapples, insurance, shipping and banking. This close-knit financial group, which is related by blood, business and long association in the Islands, is said to be tremendously powerful and influential.

385. It is not difficult to understand how, with such strong financial backing, the industry has been able to spend vast sums on research, to find the many millions of dollars necessary to finance what is possibly the most remarkable soil conservation programme in the world, to replace still-serviceable machinery with ever more efficient equipment, and to advertise and expand in the grand manner in order to increase sales and thereby reduce costs.

Trade Associations.

386. The eight companies constituting the industry to-day, are no longer self-contained or self-sufficient; they have learned to their cost that they need to be firmly united for the promotion and the protection of their mutual interests.

387. The severest jolt occurred between 1929 and 1932. The 9,000,000 cases of cut fruit produced in 1929 exceeded market requirements, so, in order to relieve the situation, they started to produce juice on a large scale. The pack in the following year jumped in consequence to 12,000,000 cases but, in the absence of proper market preparation, the juice was largely unsaleable. The next year was the year of world-wide economic depression when the whole price structure collapsed. At a time when ware-

houses were full, there were wholesale cancellations of orders and fruit had to be left to rot in the fields. It is said that the industry suffered a loss of U.S. $28,000,000.

388. To stabilise the industry, to balance production and demand, to arrange strict quotas for the companies operating, and to organise a co-operative sales campaign, the participating companies established the Pineapple Producers Co-operative Association in 1932. Simply expressed, the object was to sell as much canned pineapple as possible, and to prevent individual canneries producing more than could be sold. This Association succeeded in disposing of the tremendous accumulation of packed stock, and thereafter the steady expansion of the industry was resumed.

389. Subsequently, a price-fixing pool was established as a co-operative association under the Volstead Act, whereby pineapple growers could combine with anti-trust exemption. The legality of this arrangement was subsequently challenged and the co-operative pool had to be abandoned. Now, there is no longer any restriction of production, allocation of quotas or price-fixing.

390. To-day, the Pineapple Growers Association of Hawaii is a simple trade association, with head offices in San Francisco. It arranges the collective advertising for the industry, prepares statistics, issues scientific, industrial and commercial abstracts in the form of a monthly bulletin, and watches legislation, freight rates, import and export regulations, and the market for canned goods. It is the link between the industry and government, and it defends the industry in legal and other difficulties. The Association has a useful arrangement for the exchange of patents on a royalty basis between its members.

391. The companies are in other respects operating on a competitive footing, and their individual costs of production are a close secret. Some idea of the average cost of production can be obtained from trade statistics which indicate that the equivalent f.o.b. cost of production in Hawaii is less than $16 per standard Malayan case.

Staff.

392. The organisation of the individual companies vary according to size. It is humorously said that, properly organised, the pineapple can carry more overheads than any other fruit in the world. The largest company, based

on 26,000 acres of pineapples and responsible for 40 per cent. of the total pack appears to bear this out. It is very highly organised and efficient in consequence of having a large force of highly-trained executives and specialists; a company based on 4,500 acres apparently provides a sound economic unit; but companies smaller than this are too small to carry specialist officers on their staffs although their divisional superintendents are trained men from colleges on the mainland (U.S.A.).

393. The organisation of the largest company is roughly as follows:—

President.

Board of Vice Presidents.

Personnel Department	Service Department	Production Department	Sales Department
Staffing	Accounts	Plantations	Marketing and broking.
Labour relations	Research	Processing	Territorial sales organisation.
Public relations	Buying	Engineering	Advertising and sales promotion.
		Transport	After-sales service, and complaints.
		New developments	

394. It will be seen that each department is divided into three or more divisions, each in charge of an assistant vice-president. It follows that work in the pineapple fields comes under the control of four specialist chiefs, production, research, staffing and accounts. There is also a co-ordinating plantation manager on each of the two plantations, who are both supported by teams of specialist superintendents and their assistants. The sub-divisions are (*a*) land preparation and contouring, (*b*) planting, (*c*) field maintenance, (*d*) crop harvesting, and (*e*) machine maintenance. The cannery and research branch is similarly organised into specialist sub-divisions, as previously described.

395. Additional to the technical staff there is the trained staff on the administrative and commercial side.

One interesting section of the administration is the division of public relations which is responsible for press releases, the preparation of informative brochures and pamphlets, and the publication of the staff magazine. Thus the public, the staff, and employees are kept fully informed about the affairs of the company, its financial position, the division of revenue, the company's views on controversial matters, new developments, new inventions and new products, the opportunities for seasonal and permanent employment, social activities and staff welfare.

396. It can be appreciated what a large force of trained executives is required to maintain a high standard of industrial efficiency, to develop new processes and ideas and to ensure that this already-large organisation continues to expand on a sound basis.

397. The medium-sized organisation is about one-sixth of the size of the largest company. It can carry essential specialists but fewer overheads. The cannery is situated on one of the less populated islands where the staff and employees live together in a small township. The organisation consisting of fourteen trained executives is as follows:—

General Manager

Three Departmental Superintendents, covering:—

Office	Plantation	Cannery
Accountant	Two field superintendents	Chemist
Labour relations officer	Labour supervisor	Chief Engineer
		Planning „
		Electrical „
		Mechanical „

398. The outstanding characteristics of this company are close team-work and self-reliance. Ingenious mechanical devices for use in the field and factory, and elaborate machines for harvesting and conveying fruit have been invented and developed in the workshops on the plantation. There is little outside dependence on suppliers of plant and machinery except for standard items of equipment used in food industries which can be more cheaply produced on mass-production lines in America. Its commercial side is managed by an agency house in Honolulu.

399. The smallest companies are approximately one-twentieth the size of the largest organisation, and their annual outputs are probably each of the order of about half a million fiberite cases per annum, being based only on about 1,500 acres of pineapples. These too have their commercial organisation in Honolulu while the college-trained staff on the executive side is made up of a general manager with six superintendents in charge respectively of the plantation, the cannery, workshops and transport, office, accounts and labour.

400. These companies maintain their plantations and design and build mechanical sprayers and harvesters in the same way as the larger companies, but the superintendents are responsible for everything in their departments and there are no specialists. Naturally these small companies can carry fewar overheads than the larger companies but the same basic principles of planned field operations and continuous line mass production methods in the cannery are followed.

LABOUR.

401. The plantation and cannery employees are mostly Americans of Japanese, Philippino or Puerto Rican ancestry. The Japanese predominate at present, but the ratio is changing as their children are inclined to move up into the business and professional classes, and do not seek employment in the industry. The Japanese are very mechanically minded and the skilled operatives, foremen and technical assistants are mostly Japanese.

402. Wage rates have risen from 17 U.S. cents per hour in 1929 to 97 U.S. cents per hour, the minimum rate in 1948. This steep upward trend was initiated during the war. Honolulu was then used as a base for operations in the Pacific; high wages were offered to attract workers into war industries, and there was in consequence a very acute shortage of labour in the pineapple industry.

403. Since the war the demands by labour for wage increases have become more insistent, and it is obvious that only by increasing mechanization has the industry been able to continue to produce at a competitive price. Fortunately, and no doubt owing to the American way of life, the workers have co-operated in the application of labour-saving machinery and labour-easing devices, and appear to prefer the use of machines to laborious physical labour. Mechanization has given them opportunities for skilled

employment with higher pay, and there appears to be little risk of unemployment as production continues to rise.

Labour Relations.

404. At one time, the employees had a separate union on each plantation; these have since been consolidated into the Pineapple and Cannery Workers Union, Branch No. 152 of the International Longshoremen and Warehousemen's Union (ILWU), which in turn is affiliated to the Congress of Industrial Organisations (CIO). The ILWU represents the employees in collective bargaining negotiations.

405. The eight pineapple companies are members of the Hawaiian Employers Council which is the employers' negotiating unit. The Department of Labour and Industrial Relations in Honolulu provides for mediation, conciliation and arbitration, and approves the agreements and any subsequent wage adjustments between the parties.

406. A complete evaluation and classification of jobs in the entire industry was prepared by the Employers Council, and this was used as the basis for negotiations in 1946. The analysis of each job was based on twelve factors: educational requirements; experience necessary; skill; judgment and initiative; physical effort; mental attention; visual concentration; working conditions; accident and health risk; responsibility for the work, for the safety of others, and for plant and material. All jobs were thus rated as one of twelve grades on a graduated scale of wages.

407. A contract was drawn up between the parties which fixed the basic rates, as from 1st May, 1946, at 65 U.S. cents per hour for plantation male employees, and 80 U.S. cents per hour for factory male employees, and the rates for other jobs were in accordance. The contract provided for wage adjustments from time to time, according to the cost of living, and for overtime rates at a time and a half, in excess of the standard 8 hour day, or the standard 44 or 48 hour week for the cannery and plantations employees respectively.

408. Other clauses in the contract relate to seniority, leave of absence, holidays, and grievance procedures, and there is an assurance by both parties that there will be no interruptions of operations by strikes or lock-outs. The contract has to be renewed annually unless amended within two months of expiration.

409. Government requires that the employers must maintain all permanent employees in continuous employment, even though there may be periods when there is no work. This is why, on some plantations, pineapples are deliberately planted for harvesting in the off-season and why it is necessary sometimes to revert to hand-weeding so as to keep labour employed. The employers may however employ cannery workers in the field in the off-season if the cannery is not in operation.

410. This apparently sound agreement did not prevent a strike in the following year right in the peak of the season, when fruit had to be left in the fields to rot. An agreement was finally reached, but by March 1948 the minimum wage rate* had risen to 97 U.S. cents (Straits $1.94) per hour. Other rates are: surveyors, truck and tractor drivers U.S. 1.25; electricians, machinists and mechanics U.S. $1.45; tool-makers U.S. $1.65. The overall average wage of different companies appears to lie between U.S. $1.07 and $1.10 per hour.

411. The high standard of living of the American people, and the steady rise in the cost of living due to gradual inflation, in the absence of price controls, appear to be the underlying reasons for these extraordinary high wage rates which far exceed those of pineapple workers in other parts of the world. For instance in the Philippines the minimum wage rates are said to be U.S. $1.00 per day, and in Mexico and Puerto Rico only 15 U.S. cents per hour.

412. Even so, the pineapple canning industry of Hawaii must still continue to sell at a competitive price in the face of heavy competition from the American food market where over 200,000,000 cases of fruits are packed annually, including 40,000,000 of citrus juices which are the chief competitors of pineapple juice. In order that the companies may continue to produce at a profit, every conceivable device has to be used to increase the output per man-hour. It has been necessary to effect a labour reduction of 6 to 1 in some operations, and at the same time expand production by the complete utilisation of the whole of the fruit.

413. Both the sugar and the pineapple industry are now experiencing acute difficulties, due to these soaring wage rates, which are fast becoming the limiting factor in

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* It has since been increased.

production, and an economic crisis appears to be inevitable. Marginal sugar lands are already going out of cultivation and, as pineapples still show a small profit, this land is likely to be planted with pineapples, so as to increase production. Thus the exports from Hawaii may be expected to continue to increase at a time when there is a glut of other canned fruits on the West Coast of America.

Welfare.

414. Employees still enjoy the benefits of holidays with pay, retirement insurance, group life insurance and sick leave pay, but otherwise the perquisites system has been completely abandoned in favour of a simple straightforward wage contract between the employers and the workers.

415. A recent contract with the Union provided that the employers could discontinue perquisites to plantation employees on a certain date in consideration of an upward adjustment in wages in compensation. On that date housing, recreational and welfare activities and utility and medical services, formerly free, ceased to be the concern of the companies.

416. Prior to this date, the leading company provided on 'pineapple island' excellent housing for its employees, with sewage, water, lighting, garbage collection, bus service and fire services free. A group hospital and welfare service resulted in good health and low mortality rates, and the company maintained a city park, golf course, children's playground, sports arena, gymnasium, and a cinema. The streets of this pineapple township were maintained by the company. The Territorial Government was responsible only for law and order, education, the maintenance of the main roads and the airport, and the conservation of the forest reserves.

417. Under the new arrangement, all such community services were taken over by a non-profit-making Community Trust; the medical services were handled by the Hawaiian Medical Services Association, housing by a Housing Company, with a board elected by the employees, and sports, entertainment and social welfare by a Welfare Association also managed by representatives of the employees.

418. The employees continue to live in the same houses as before but they can choose their homes and can live where they wish but they have now to pay rent. All

existing houses were leased by the pineapple company to the Housing Company at an agreed price, and any new houses erected are taken over on completion. The latest houses for the plantation labourers have 3 bedrooms, a living room, a bathroom, a kitchen, a garden, and a garage for two cars. It is electrically-equipped with a radio, refrigerator, washing machine, water-heater and stove.

419. The Pineapple Company makes donations in aid, finances new housing and improvements, and gives every support and encouragement to the Trust in its work.

THE COMMERCIAL SIDE.

420. For five of the companies, the factor or agency system takes purchasing, selling and advertising out of the hands of the pineapple companies; two of the companies are part of large mainland (U.S.) corporations, and canned pineapple is only one of their many nationally-advertised canned, bottled, and quick-frozen products; the third and largest company, with its head office in Honolulu, maintains its own sales and advertising organisation and a territorially-organised sales force in the United States with offices in New York and San Francisco.

Advertising

421. Hawaiian pineapple is said to be the first of all food commodities to have been advertised co-operatively, its first campaign having antedated that of 'Sunkist' oranges by a few months. The first co-operative advertising campaign was opened in 1909. A sum of U.S. $50,000 was spent in magazine advertising, using the slogan "Picked ripe, canned ripe". This investment cleared out all surplus stocks.

422. There was a second campaign in the period 1913-1915, when the average pack was equivalent to about 1,000,000 Malayan-size cases, and the amount spent on advertising in these three years was U.S. $100,000. Once again the surplus stocks were moved and the campaign allowed to lapse.

423. The longest campaign ran from 1921 to 1928, when stress was laid on the domestic uses of canned pineapple in salads, desserts, for pastries and also with sweet dishes. New recipes were widely distributed, informative articles were published and sales expanded from 3,000,000 to 4,500,000 Malayan-size cases over this period.

424. A further co-operative effort was made in 1932 by the Pineapple Producers Co-operative Association, previously mentioned. In 1931 the industry had packed the equivalent of 6,500,000 Malayan-size cases then worth approximately U.S. $20,000,000. Unfortunately this was the year of world-wide economic collapse when the whole price structure broke down. Even so, the vast sum of U.S. $1,500,000 spent on press advertising and on dealer education saved the situation and effected the disposal of an enormous accumulation of packed stock; whereafter production was again resumed on a steadily-expanding scale.

425. On this occasion, press copy featured the health appeal of pineapple juice and the ready-to-serve nature of canned pineapple. 'Pineapple cup', an attractive sundae of crushed fruit, was introduced into restaurants, clubs and hotels, and aboard steamers and trains. A programme of stimulated retail sales was introduced, founded on the fact that the average consumption per person in the United States was then only about one slice per person in every sixty meals. As previously stated the primary object was the satisfactory disposal of by-product fruit and juice.

426. In addition to the general programme of advertising, four of the canneries also carry out their own campaigns. The basis of such advertising is the printed, poster or verbal repetition of a trade name or brand, coupled with visual repetition in the retail store of a single easily-recognisable coloured label for all the products of that one company, the only variations on the label being in the description of the contents, and the quality grade, which is clearly stated.

The Tourist Industry.

427. The pineapple and tourist industries are closely related and complementary. For many years, the American public has learned to associate the pineapple with Hawaii through articles and advertisements which use the colour and romance of the Islands to attract the interest of the reader. This, in turn, has served to attract tourists to Hawaii in their many thousands.

428. The arrival of every liner from the Mainland is the excuse for a 'fiesta'. The first recognisable landmark the tourist sees is a giant pineapple on stilts over-topping Honolulu. A motor-boat bearing a hula dancer and her

attendant musicians circles the ship, and later, as the ship ties up, the Royal Hawaiian Band plays Island music, and a Hawaiian lady clothed in ceremonial dress greets the visitors with the "Song of the Islands". Every single visitor is assured of a personal welcome, he or she is presented with floral leis, and receives the traditional kiss. At no time is there any touting or appeal for money.

429. The traveller, sooner or later, proceeds to the leading hotel where pineapple juice gushes freely from a fountain, an intriguing though potent fruit cup is offered in the scooped half of a pineapple, and the many uses of pineapple are demonstrated in the menu.

430. The leading pineapple company makes a speciality of receiving and entertaining tourists. There are organised trips through the pineapple country where the visitor is encouraged to eat as much of the golden fruit as he wishes. Also, on every operating day, there are frequent tours of the cannery. Groups, gathering in the colourful reception room, imbibe pineapple juice while waiting to be taken round by one of a team of eight charming hostesses, dressed in pineapple yellow and green and each wearing a yellow hibiscus in her hair.

431. The theme of island romance also runs through two delightful films "Treasure Islands" and "A Story of Paradise" which possess both tourist and consumer interest. They were produced professionally in sound and colour at a cost of about U.S. $100,000 each. One of these concludes with a series of close shots of prepared foods which are strikingly effective and appealing.

432. While the underlying idea of all this colourful advertising is the continuing expansion of the industry, it needs to be emphasised that the production of pineapple by-products demands adequate advertisement. It is of little use producing products for which there is no demand, and the production of many millions of cases of chipped or crushed pineapple and pineapple juice from pineapple waste without adequate market preparation to create demand is to invite disaster.

The Market Position.

433. There is said to be an unsatisfied and preferential demand for canned pineapple products, even though there is a big accumulation of other canned fruits and juices in America at the present time. The enthusiastic accep-

tance of fresh frozen pineapple by the trade and by customers also indicates that this new product can be distributed in increasing volume on a sustained basis. The unprecedented increase in the birthrate in the United States, and the steadily rising standard of living has in consequence lead to the conclusion that the potential demand for pineapple products is still greatly in excess of existing production facilities.

434. It appears that the limiting factors to the further expansion of the industry in Hawaii are the supply of fruit and the present high cost of production. Mexican sliced pineapple is quoted at U.S. 50 cents per fiberite case cheaper than Hawaii, and it is apparent therefore that the cost of production in Mexico is at present less than $14 per Malayan-size case. Since modern machinery and continuous production lines are now to be introduced into Mexico, the implication is obvious.

Overseas Developments.

435. To ensure the continued stability of their business, the leading pineapple companies of Hawaii have been compelled to extend their activities to other countries in order to obtain sufficient fruit to meet increasing demand, and to place themselves on a sound footing to meet competition should a slump in prices occur.

436. The paramount consideration is of course the availability of suitable land for growing pineapples. There may be land-leasing difficulties, an absence of law and order, or excessive bureaucratic interference with the possibility of the ultimate nationalisation of any successful enterprise. In some countries it is difficult, perhaps even impossible, to bring in supplies of fertilisers, squashed cans, or tinplate, or to export the canned product owing to import and export restrictions, prohibitive duties, soaring inflation, seizures of currency, or the necessity for barter deals. These are the factors which have had to be taken into consideration when considering any such overseas developments.

437. The most promising country, from the point of view of growing the fruit, appears to be Formosa (or Taiwan) where the Japanese had established a promising canning industry before the war. Japanese technicians then occupied all the key positions while the Formosans did the unskilled work. When the 160,000 resident Japanese were expelled, they took their knowledge and skill with them

and in consequence the industry has died. At the present time, the unsettled state of the country discourages its revival.

438. Mindanao in the Philippines was already a proven territory before the war. An American company from Hawaii has now re-established itself at Del Monte in the Cagayan valley where it has a lease of 25,000 acres. Post-war production started in the second quarter of 1948 and shipments from April to September amounted to 828,460 cases, valued at U.S. $3,981,143. The factory is ultimately expected to produce six million cases a year.

439. Mexico is reported to be a country with almost limitless possibilities for growing pineapples, and in the States of Vera Cruz and Oaxaco alone, there are 25,000,000 acres of good pineapple land. There are stated to be seven canning plants now operating, some of which are equipped with modern canning machinery, and in addition six other companies, based on American capital, are studying the possibilities.

440. Further important developments are also to be expected in Cuba and Puerto Rica in Central America where Hawaiian companies have been carrying out test plantings, and where pineapple canning is already an established industry.

Plant Sales.

441. The industry has an arrangement for the mutual interchange of patents on a royalty basis.

442. The following is a list of the main items of plant, evolved by plantation engineers in Hawaii: the paper-laying machine; various types of mechanical sprayer; the escalator lorry; various types of mechanical harvester; the Ginaca peeler, corer, and eradicator; the multiple slicer; the automatic chip and chunk cutter; the pre-vacuumiser; the vacuum multiple can lifter; a continuous cooker and cooler; an automatic tray filler and tray stacker.

443. It was stated that the programme of mechanization and replacement is still behind-hand in Hawaii owing to the war, and that a great deal still remains to be done. Every cannery visited was replacing new plant for old, or automatic machines for erstwhile physical operations; the workshops were busy, and they are not equipped to manufacture plant for sale overseas.

444. The Ginaca peeler, corer and eradicator is undoubtedly the key to mass-production methods. High speed machines of the very latest design are not available for sale, but second-hand machines, patented in 1924, might be procurable but, though still usable, their purchase is not recommended. It is understood that slow Ginaca machines, based on an earlier patent, and operating at between 20 and 45 fruits per minute, can now be bought from two plant manufacturers. One is in the United States and the other in Australia. There is also a semi-automatic peeler and corer which can deal with about 6 to 8 fruits per minute, but it does not top and tail the fruit. It was emphasised that neither the automatic nor the semi-automatic machines are of any use where the fruit is round or barrel-shaped, owing to the low-yield of cut fruit.

445. Of undoubted importance to Malaya is the pulp eradicator for scraping the skins to obtain pineapple crush and juice. This is now produced and sold as a separate machine, and was seen in successful operation in a factory in California.

446. The continuous multiple slicer is a sound and sturdy job for slicing fruit cylinders of standard diameter which are obtained from the semi-automatic peeler and corer, and from the fully automatic Ginaca, but not by hand-peeling. This machine which was seen in successful operation in California and Hawaii, is recommended, and is available for purchase from a plant manufacturer.

447. The fully-automatic chip and chunk cutter is a simple machine, evolved and patented by the leading company in Hawaii. It is likely that ultimately all the companies will adopt this machine to replace their existing semi-automatic devices. It produces a near-cube or a fluted chip of standard size.

448. The boom harvester is unsuitable for use in Malaya, but the escalator-lorry for collecting fruit may solve the problem of excessive bruising, due to throwing the fruits into the lorries.

449. Steel rail, both heavy and light gauge, was available for purchase at a very high price. The Hawaiian Railways have closed down owing to competition from road transport, and light railway track, both permanent and portable, on the sugar plantations is all being taken up because the mechanical grab, with truck delivery, has now replaced the hand-cutting of sugar cane.

THE RECONSTRUCTION OF THE PINEAPPLE INDUSTRY OF MALAYA.

DISCUSSION AND RECOMMENDATIONS.

450. In 1939, the year during which the second world-war started, the shipments of canned pineapple from Singapore reached the record of 2,725,279 cases containing over 100,000,000 tins, and worth nearly $10,000,000. However, during the Malayan campaign and the subsequent occupation of this country by the Japanese, the industry suffered virtual extinction and has since had to be restarted, practically from the beginning.

451. Of the eight canneries which were operating in 1939, one was deliberately burnt down as a scorched-earth measure; two were used as strong-points by the Australians during the battle of Kranji, when the Japanese crossed the Straits: one was the storm-centre of the desperate fighting around Kallang Airport during the last hours of Singapore; and the remainder suffered serious dilapidation through looting and neglect during the occupation, when the Japanese removed most of the tools, equipment and machinery from any factory which was not operating.

452. After the defeat of the Japanese, the Chinese owners, with courage and determination, set about the task of reconditioning their canneries. The buildings, which fortunately were of solid concrete construction, were re-roofed and renovated, but it was at first quite impossible to obtain new equipment. It was necessary to trace and re-install the original plant and machinery, even though, when found, it was usually rusty, damaged or lacking in essential parts. By the end of 1947, six canneries, two in Johore, one in Selangor and three on the island of Singapore, had been reconditioned, and approved for operation.

453. The plantations, mainly in the upland areas of South Johore, had suffered even more than the canneries. During the initial period of occupation, following a series of massacres in South Johore, the growers abandoned their lands and took to the jungle. The upland areas in consequence became rolling sheets of lallang and gradually reverted to secondary jungle growth. Smaller areas of low-land peat soils around the Pontian District in south-west Johore and in the Klang District of Selangor suffered through the rise of the water level following the choking

of the drains with weeds and of the rivers with water hyacinth. Thus, on the cessation of hostilities, of the original 58,000 acres of canning pineapple, scarcely 3,000 acres were good enough to be worth reconditioning.

454. Government was aware of the serious plight of the industry, and, in May 1947, appointed a Special Pineapple Committee under the chairmanship of the State Agricultural Officer, Johore. The Committee also included the chairman of the Central Board of Pineapple Packers, and a number of senior government officers to advise on the agricultural, industrial, commercial, economic and sociological aspects of the various problems of the industry. The Committee's final report, which contains some thirty recommendations, was submitted in February, 1948, and in essentials has the approval of the Governments of the Federation of Malaya and Singapore. The industry is now engaged in putting into operation the initial stages of a comprehensive scheme of reconstruction.

455. In the same year the writer was sent to Hawaii to study the industry and see what developments had occurred during the war years. In discussing the subject and submitting recommendations for the Malayan pineapple industry he has been set a very difficult task because of the wide differences in conditions, in outlook and in the financial organisation of these two industries.

456. The Hawaiian pineapple industry is a heavily-capitalised and highly-mechanized business and yet, with far higher wage rates than Malaya, is able to produce more cheaply. If the same co-ordinated efficiency and mechanical ingenuity and the same policy of dynamic expansion is transferred to countries where wages are lower than in Malaya, there is an almost certain prospect of very severe competition in the future, and a policy of "laissez-faire" would undoubtedly have serious consequences. Every means of securing greater efficiency and reducing production costs therefore needs to be examined.

457. It must be understood at the outset that the methods practised in Hawaii are not necessarily suitable or immediately suitable for the Malayan pineapple industry. There are, for instance, the striking differences in climate and soils, and the fact that an entirely different variety of pineapple is grown. Cultivation is also in the upland regions, whereas in Malaya the crop is being restricted to the lowland peat areas.

458. There are also fundamental differences in outlook to be considered. American employers work on the principle that a policy of vigorous expansion will create new employment, reduce prices, and ensure the continued stability of their businesses; the Japanese-American and Philipino-American workers co-operate in the introduction of labour-saving and labour-easing devices, and demand a high standard of living which they are intelligent enough to realise can come only through increased productivity. Then there is their attitude towards advertising as an essential adjunct to this policy of dynamic expansion. It is frequently pointed out that the Americans are favoured by a large domestic market, but is not the British Empire also a large and ever-expanding market?

459. Except for the multiplicity of coloured labels, of which few have ever had any real selling value, the Malayan pineapple industry has done practically nothing to create a demand either in Europe or in the British Empire for canned pineapple or its by-products. Even if it had, this under-capitalised industry of small units, based on batch-processing and chained to cheap hand labour, could not readily have responded to such a vast and progressive increase in demand as has occurred over the same period of years in Hawaii.

460. Hand labour is not elastic because trained manual workers are not available when required, and in consequence it acts as a brake on the free and rapid expansion of industry. With mechanization, output can be rapidly multiplied simply by bringing in more machines; and with such rapid expansion the cost of production can be reduced, without wage reductions or dismissals. The growing needs of an increasing world population for inexpensive luxuries can thus be met by mechanized production.

461. It is true perhaps that in the change-over from manual production to mechanized production, a temporary displacement of workers does sometimes occur. But the Malayan pineapple industry will be steadily expanding during the next ten years as the new areas now being opened up in Johore and Selangor begin to yield fruit. Thus there need be no fear of unemployment; on the contrary, mechanization in Hawaii has rapidly built up a vast and still expanding industry and has increased employment in

that industry. Further, the workers have attained a higher status and receive higher pay as skilled operatives than they otherwise would.

462. Stream-lined production, or the continuous flow of work, is the keynote of modern industry. Here, in Malaya, change-over to this stream-lined production must necessarily be introduced gradually as circumstances and finances permit. The industry has already agreed to make compulsory, in all canneries, the use of certain machines which materially improve the quality of the product and at the same time constitute integral parts in stream-lined production. A further step in the mechanization process will be the machine-cutting of the fruit. At present each fruit is peeled, cored and sliced individually by skilful men, armed with sharp knives. They are quick and dexterous but nevertheless they take 2 minutes to complete the whole operation, whereas the latest peeling, coring and slicing machines, operated by a team of two men and three girls, are each able to deal with over 100 fruits a minute.

463. A third essential requirement is the profitable utilisation of the whole of the fruit. At present less than 20 per cent. of the whole fruit is canned; the rest of the fruit, the so-called " waste ", is not only a total loss, but also a serious nuisance. The machine, known as the eradicator, is able to scrape white pulp from the inside of the skins, and this could be converted into pineapple crush, jam and juice, or else into canning syrup, so saving sugar. The coarse green " outers " could be crushed, pressed, ensiled and so converted into a coarse feed for livestock, such as pigs and dairy cattle, which could provide an associated industry.

464. A fourth requirement is planned and co-ordinated operation in field and factory. Until recently, supplies of fruit were obtained with competition not only between the operating canneries but also from the fresh fruit trade, and gluts of fruit and shortages occurred at irregular intervals. Occasionally, during a period of glut, as much as five days might elapse between cutting and canning. This resulted in loss of fruit through rotting in storage and encouraged the practice of cutting unripe fruit to prevent such rotting. As a first step the industry has established a clearing station from which consignments of fruit are directed to the different canneries, and a sliding scale of prices has now been agreed upon between the canners and the growers.

465. This is only a beginning. It will be appreciated from the third section of this report (" Cannery Practice ") that stream-lined production demands planned operations to secure full efficiency. It is essential to plan harvesting to ensure regular deliveries of fruit so as to maintain the machines in continuous operation, and also, in the peak of the season, to operate day and night, in shifts, to smooth out deliveries, so as to operate with fewer machines than would otherwise be required.

466. Futhermore, to obtain the best results, pineapples should be harvested only when ripe, should be gently handled, transported expeditiously, and rapidly processed within 24 hours of cutting. At present, this is regarded in Malaya as an ideal that is impossible of attainment in view of the erratic deliveries from the existing small growers and the disturbed conditions in the pineapple areas. When the plantations come into bearing, it should be possible to organise deliveries so that the fruits are cut as close to the ideal condition of ripeness as it is possible to get.

467. A fifth requirement is proper technical control in field and factory, with greater supervision to ensure systematic work and rigid adherence to agreed standards of quality, and to prevent malpractices which otherwise inevitably occur (See Section E—Technical Instruction and Control).

468. The sixth and most important requirement of all is research on far more ambitious lines than has hitherto ever been attempted in Malaya. In Hawaii, the opinion was responsibly expressed on several occasions that the vast sum spent there on research was an essential expenditure which on several occasions had saved the industry from disaster and was primarily responsible for its success.

469. Here in Malaya a first step in canning research will be to find subsidiary industries which would make it possible to provide year-round employment for the employees since pineapples are harvested during 7 months only of the year. Contrary to a previously expressed opinion, there are other Malayan fruits and vegetables which can be produced on a plantation scale and canned satisfactorily. Canned " Hawaiian Breakfast " papaya and canned " Belimbing Buloh " for instance are the equal and almost the exact equivalent of canned apricot and canned greengages. Then there is that vitamin-rich, free-growing

weed, Amaranth, the Malayan spinach, which in canned form should find a ready-market in countries where green vegetables are practically unobtainable. Tropical fruit salad, canned foods containing fish, fowl or meat and based on rice, macedoine of tropical vegetables and other oriental foodstuffs, all require systematic investigation.

470. It can safely be predicted that the preservation of food surpluses will assume increasing importance as the worlds population continues to increase and the world production of foodstuffs continues to be unable to keep pace. That is why the new industry of quick-freezing is so important. (See Section D—Subsidiary Industries). Fresh frozen foods, a luxury to-day, can, by mass production methods, become tomorrow's cheap necessity.

471. The Canning Research Station at Johore Bahru has been completely re-equipped by Government for small and medium-scale processing trials and for the laboratory investigation of the many technical problems of the industry. Field investigational work is to be started at the Federal Government Experiment Station at Pontian in South-West Johore as soon as the present emergency is over.

472. The problem of first importance will be plant-breeding to obtain pineapples of uniform size and cylindrical shape, suitable for machine-cutting, in addition to other desirable characteristics. Problems of management of peat soils and mechanical cultivation on this terrain will also be studied at this Station with a view to improving yields, flavour, texture and quality of the fruit.

473. This, in rather brief outline, is a review of the major problems of the Malayan pineapple industry. With the speedy yet cautious introduction of modern methods in field and factory, and a change in commercial outlook, there is no reason why this industry should not be able to compete successfully and continue to expand to meet the steadily growing needs of an increasing world population.

SUMMARY.

Section A—GENERAL.

1. The pineapple industry in Hawaii started from the same humble beginnings and at about the same time as the Malayan pineapple industry.
2. The turning point in the fortunes of the industry came in 1906 when a factory for the manufacture of the machine-made can was established at Honolulu.

Section B—FIELD PRACTICE.

3. By the lavish expenditure of capital, returned many times over, pineapples have been successfully cultivated on upland soils in Hawaii.
4. By operating in four-year cycles, ploughing in old plants, and regularly renewing major, minor and trace elements in the soil, by regular soil fumigation, by the careful elimination of weeds, and by the suppression of pests, it is possible to plant the same land repeatedly with pineapples.
5. Two types of pineapples are grown in Hawaii for canning: the Hilo and the smooth Cayenne. The latter is said to correspond to the Sarawak pineapple, its size having been reduced and its shape improved by selection and close-planting. The average plant population is 17,454 per acre.
6. Hormones, the new chemical growth-promoting substances, have been used experimentally to change the nature of the plant, to produce larger, firmer fruit, to concentrate the crop, to delay or accelerate harvesting or to obtain more planting material. They have also been used on the plantations to destroy old plants and weeds.
7. The harvesting of the crop is a planned mechanical operation. The fruit is not handled again, after it has been cut, until it is being processed in the cannery 24 hours later.

8. Ninety per cent. of plantation operations in Hawaii are mechanized. This includes road-making, terracing, knocking down old fields, ploughing, harrowing, soil fumigation, weed destruction, mulch paper laying, the application of fertilisers, hormones and pest sprays, and crop harvesting.

Section C—CANNERY PRACTICE.

9. Stream-lined production, or the continuous flow of work and the continuous removal and utilisation of the so-called pineapple waste, is the keynote of production in Hawaii.

10. A single pineapple passes through the entire sequence of processing operations in about 15 minutes in the largest and most modern cannery.

11. The record day's pack in this cannery was 2,691,335 pineapples, equal to 5,600 tons of fruit, which produced the equivalent of 120,000 Malayan-size cases of canned fruit and juice.

12. Ninety per cent. of the cannery operations are mechanized. Trimming the fruit cylinders and grading the cut fruit are the only manual operations. There is no human lifting or carrying, and virtually no pedestrain traffic within the canneries.

13. Cans are manufactured for the industry by an independent company in five standard sizes. The total output is 400,000,000 cans per annum.

14. The cut fruit is packed in water, sweetened and unsweetened pineapple juice, concentrated juice, or ordinary sugar syrup. The canned product is exhausted, cooked, cooled and labelled by fully automatic machinery.

15. The lavish use of costly stainless steel is a most outstanding feature in all the canneries. It is regarded as the cheapest and most satisfactory material to use in contact with cut fruit and juice.

Section D—SUBSIDIARY INDUSTRIES AND BY-PRODUCTS.

16. Shipment of refrigerated fresh pineapples from Hawaii to the United States is only on a very small scale.

17. The new process of quick-freezing has been applied successfully to cut pineapple, and the new product has been enthusiastically received by the trade and by customers in the United States.

18. Pineapple juice is no longer a minor product of the industry. The equivalent of over 4,000,000 Malayan-size cases are now produced from selected fruit and eradicated pulp.

19. The introduction of the eradicator, a device for scraping the white pulp from the inside of the skins, has made it possible to increase the yield of canned fruit and juice to over 50 per cent. of the weight of the fruit. Canning juice is recovered from the speckled pulp and the pressed green shells or skins are ensiled and used as feed for draught animals and dairy cattle.

20. In the largest cannery the bitter juice obtained from the green skins is converted into pure cane sugar solutions by an elaborate new process for use as canning syrup.

21. In several of the canneries pineapple bran is produced from the pressed waste, but the plant required is elaborate and expensive.

22. Pineapple tops, the crowns of the Cayenne pine, have been found to be superior to pineapple bran and Napier grass as a feed for cows. They are chaffed, fine-chopped or ensiled with molasses.

23. A dairy farm with 1,000 head of cattle is based on the supply of pressed pineapple waste from one of the largest canneries.

Section E—RESEARCH.

24. The growth, efficiency, and pre-eminence of the Hawaiian pineapple industry, in spite of serious production and financial difficulties,

is primarily due to exhaustive research into the problems of planting, processing and can-making by a large force of scientifically trained men and women in the United States and Hawaii, and by the careful planning and strict control of field and factory operations by qualified technicians.

25. The annual sum spent on research in Hawaii is not known, but it is believed to exceed Straits $2,000,000 for the industry, which is based only on 63,000 acres.

26. Quality control is an important function of the research side. In the largest cannery, a percentage of all fruit received is exhaustively examined on a special inspection line, a large force of women inspectors closely supervise and check the work of the trimming and grading lines, and a panel of inspectors examine the packed stocks in the warehouse.

27. Pineapple selection work is an important activity on all the plantations. Clonal selection is considered to be more profitable than cross-breeding of different varieties to produce hybrids, selection being principally for shape for machine peeling.

Section F—ORGANISATION AND THE COMMERCIAL SIDE.

28. Small-holders are to-day only a small and unimportant factor in the industry in spite of Government intervention on their behalf. Inevitably the requirements of modern industry require the strict control and organisation of production, and the small growers are forced to operate in close association with one of the canning companies by whom they are financed.

29. The small-holdings were formerly operated on a family basis, but as a result of education and the war, the sons and daughters are leaving the land.

30. The small growers now have to employ extremely highly-paid hired labour. Under-capitalised and without modern equipment,

they are finding it increasingly difficult to operate their small properties.

31. There are twelve company-owned plantations and nine canneries, based on 63,000 acres of pineapples. The eight companies are all public companies, with thousands of shareholders.

32. Two of the companies have their roots in America, the remainder are Island-owned and controlled. These six are part of an inter-locking organisation, covering sugar, pineapples, insurance, shipping and banking.

33. The Pineapple Growers Association of Hawaii is a trade association which arranges collective advertising, prepares statistics, issues a monthly bulletin of abstracts and watches legislation, trade regulations, freight rates and the market position. It is the link between the industry and government.

34. The largest company is based on 26,000 acres of pineapples and is responsible for 40 per cent. of the total pack.

35. It carries a large force of trained specialist executives to maintain a high standard of efficiency, to develop new processes and to ensure that the business continues to expand.

36. The smallest companies are one-twentieth the size of the largest, do not include specialists on their staffs, and are instead organised on the basis of divisional superintendents.

37. The minimum wage rates in this industry for men in regular employment throughout the year in field or cannery is Straits $1.94 per hour.

38. Only because of intense mechanization and the utilisation of the whole of the fruit, is it possible for this industry to produce canned pineapple at the equivalent of about Straits $16 per Malayan-sized case with existing wage rates.

39. Employees enjoy the benefits of holidays with pay, insurance and sick pay but, otherwise, the perquisites system has been abandoned in favour of a simple wage contract between the employers and the workers.

40. Advertising is carried out co-operatively, and by the larger companies also individually. The secret of the successful disposal of vast quantities of pineapple crush and juice is colourful advertising. The basis of all such advertising is the repetition of a single trade name or brand, coupled with a single easily recognisable label for the canned products.

41. The pineapple and tourist industries are closely related and complementary. Hawaii is no more colourful than Malaya but the treatment of the visiting tourist is quite different.

42. There is reported to be a growing accumulation of canned fruits and juices in America. Nevertheless there is an unsatisfied and preferential demand for canned pineapple products.

43. It is considered that the limiting factors to further expansion in Hawaii are the supply of fruit and the high cost of production.

44. To ensure the continued stability of their business, the leading companies are extending their operations to other countries where land is available and wage rates are very considerably lower. The implication of the introduction of modern machinery and mechanical field equipment into these countries is obvious.

APPENDIX I.

THE GROWTH OF THE HAWAIIAN PINEAPPLE INDUSTRY

1903-1947.

(Western Canner and Packer, Yearbook, 1939)

Production 1903-1933
Shipments 1934-1939
Production 1946-1947

YEAR	NO. OF CASES	YEAR	NO. OF CASES
1903	1,893	1921	5,262,503
1904	10,397	1922	4,770,239
1905	45,041	1923	5,895,747
1906	74,245	1924	6,825,904
1907	168,205	1925	8,728,580
1908	343,726	1926	8,939,590
1909	401,940	1927	8,879,252
1910	464,968	1928	8,663,056
1911	725,742	1929	9,210,240
1912	1,313,363	1930	12,672,296
1913	1,667,122	1931	12,807,919
1914	2,268,781	1932	5,063,793
1915	2,669,616	1933	7,815,540
1916	2,609,483	* 1934-35	11,000,000 est.
1917	2,607,031	* 1935-36	12,500,000 est.
1918	3,847,315	* 1936-37	17,000,000 est.
1919	5,071,976	* 1937-38	20,000,000 est.
1920	5,986,982	* 1938-39	15,000,000 est.
		* 1946-47	18,443,675

APPENDIX II.

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* Includes juice.

Note: The standard Malayan case is roughly twice the size of the standard fiberite carton used in Hawaii.

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Due Date	Return Date	Due Date	Return Date
12/12/70	28·11·70	31·8·76	30·8·76
6·3·71	5·3·71	14-9-76	—
20·9·71	5·9·71	10·11·76	8·11·76
11·12·71	3·12·71	23·11·76	22·11·76
13-7-72	4.7.72	7·12·76	3·12·76
29·8·73	20/8/73	18·12·76	12/12
28·11·75	15/11/78	25·3·77	15·4·77
		13·3·78	2-3-78
4·12·75	3·12·75	21·3·80	19·3·80
24·2·76	17·2·76		
19-8-76	14/8	2-9-81	11/9